AZAD GOVERNMENT OF THE
STATE OF JAMMU & KASHMIR

General and Technical Specifications for Highways & Bridges

November, 2020

PLANNING & DEVELOPMENT DEPARTMENT (P&DD)
MUZAFFARABAD, AJ&K

SAMPAK International (Pvt.) Ltd.

FOREWORD

Review and updating of General and Technical Specifications of Government of Azad Jammu and Kashmir (2013) became essential in light of new developments being planned by the government i.e. Construction of Motorways, Highways, Bridges and allied important Structures on international standards.

In order to assess the new requirements of General Specifications Sampak interacted with P&D and other Departments of AJK. Opinion of other consultants working in AJ&K was also taken, besides getting the opinions of major contractors of AJK. Sampak also widened the field studies to know the availability of construction materials in AJK.

We have carried out amendments in the current General Specifications looking to the causes of disputes and reasons of failure of certain projects constructed in various parts of AJK. Addition of new items has also been made in these specifications to cater for future needs of highway construction and bring this specification at par with international standards. The user of these Specifications is advised to exercise caution in use of various new items.

Our sincere thanks are due to several agencies, who contributed in compilation of this important document, however special attention of Planning and Development Department under the guidance of Chairman P&D, helped us to complete the assignment successfully. We hope that this document will contribute effectively in improving the workmanship and quality of highway and bridge construction in Azad Jammu and Kashmir.

For SAMPAK International (Pvt.) Ltd.
(S. M. A. Shirazi)

PLANNING AND DEVELOPMENT DEPARTMENT GOVT OF AJK

GENERAL SPECIFICATIONS

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GENERAL

1. Introduction

1.1 Preamble

General Specifications have been produced for Government of Azad Jammu and Kashmir, keeping in consideration that following types of activities are being carried out in this organization:

i) Construction of Motorways, new Highways, Bridges and allied works.

ii) Rehabilitation and Improvement of existing road network and structures.

iii) Maintenance of existing roads and structures.

All the above three aspects of construction, rehabilitation and maintenance have been covered in these General Specifications. Subsequent chapters would give a list of such items of work with an indication of their probable use, in case of the above three categories of works.

1.2 Standards

These Specifications describe the requirements and procedures for execution of work items to achieve required workmanship and quality. The materials to be used shall conform to specifications and testing procedures as per American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing and Materials (ASTM) or British Standard (BS) as indicated in their latest editions. Samples of materials for laboratory tests and their subsequent approval shall be utilized according to these references. The contractor shall provide copy of relevant standards applicable to his items of work, if required by the Engineer.

1.3 Manpower

Contractor shall also provide skilled manpower in adequate number, who can perform execution with quality and workmanship control in accordance with the requirements of the relevant work item.

1.4 Equipment

Number and kind of Equipment required for different items of work shall be planned by the contractor keeping in view the workmanship required by a particular item and the quantity of finished item required to be carried out in eight hours shift. The Engineer shall approve such planning or any changes shall be proposed for guidance of the Contractor. However, this procedure shall not relieve the Contractor of his contractual obligations pertaining to performance and maintenance of project.

1.5 Alternative Equipment

Few of these specifications may provide that equipment of a particular size and type is to be used to perform portions of the work. It is to be kept in mind that the deployment and use of new or improved equipment will be encouraged.

The Contractor may request, in writing, permission from the Engineer to use equipment of a different size or type in place of the equipment specified or recommended in these chapters.

The Engineer, before considering or granting such request, may require the Contractor to furnish, at his expense, evidence to satisfy the Engineer that the equipment proposed for use by the Contractor is capable of producing work equal to or better in quality than, that which can be produced by the equipment specified.

If such permission is granted by the Engineer, it shall be understood that such permission is granted for the purpose of testing the quality of work actually produced by such equipment and is subject to continuous attainment of results which, in the opinion of the Engineer, are equal to, or better than, that which can be obtained with the equipment specified. The Engineer shall have the right to withdraw such permission at any time when he determines that the alternative equipment is not producing work of equal quality in all respects, to that which can be produced by the equipment specified. Upon withdrawal of such permission by the Engineer, the Contractor will be required to use the equipment originally specified and shall, in accordance with the directions of the Engineer, remove and dispose off or otherwise remedy, at his expense, any defective or unsatisfactory work produced with the alternative equipment.

Neither the Employer nor the Contractor shall have any claim against the other for either the withholding or the granting of permission to use alternative equipment, or for the withdrawal of such permission.

Nothing in this clause shall relieve the Contractor of his responsibility for furnishing materials or producing finished work of the quality specified in these specifications.

1.6 Storage of Materials

Articles or materials to be incorporated in the work shall be stored in such a manner as to ensure the preservation of their quality and fitness for the work, and to facilitate inspection.

1.7 Defective Materials

All materials which the Engineer has determined as not conforming to the requirements of the drawings and specifications will be rejected, whether in place or not. They shall be removed immediately from the site of the work, unless otherwise permitted by the Engineer. No rejected material, the defects of which have been subsequently corrected, shall be used in the work, unless approval in writing has been given by the Engineer. Upon failure of the Contractor to comply promptly with any order of the Engineer made under the provisions in this clause, the Engineer shall have authority to cause the removal of rejected material and to deduct the cost thereof from any payments due or to become due, to the Contractor.

1.8 Quarry Materials

Quarry material is rock, sand, gravel, earth, or other mineral material, other than local borrow or selected material, obtained on the project. Quarry material does not include materials, such as cement, lime, marble powder etc. obtained from established commercial sources.

Quarry Materials shall be furnished by the Contractor from any source he may select, except that when mandatory local sources of certain materials are designated in the Special Provisions, the Contractor shall furnish material from such designated mandatory sources.

The furnishing of quarry materials from any source is subject to the provisions of "Examination of drawings, specifications and item of Work".

Unless approved in writing by the Engineer, material sources shall not be excavated at locations, where the resulting scars will present an unsightly appearance from any highway or may cause land sliding. No payment will be made for material obtained in violation of this provision.

The Contractor shall, at his expense, make any arrangements necessary for hauling over local public and private roads from any source.

Full compensation for furnishing all labour, materials, tools, equipment, and incidentals, and for doing all the work involved in conforming to the provisions in this clause, for furnishing and producing materials from any source, shall be considered as included in the price paid for the contract item of work involving such material and no additional compensation will be allowed therefor.

1.9 Trade Names and Alternatives

For convenience in designation on the plans or in the specifications, certain articles or materials to be incorporated in the work may be designated under a trade name or the name of a manufacturer and the catalogue information. The use of an alternative article or material that is of equal quality and of the required characteristics for the purpose intended will be permitted, subject to the following requirements:

The responsibility of proof, as to quality and suitability of alternatives, shall be upon the Contractor and he shall furnish all information necessary as required by the Engineer. The Engineer shall be the sole judge, as to the quality and suitability of alternative articles or materials and his decision shall be final.

Whenever the specifications permit the substitution of a similar or equivalent material or article, no tests or action relating to the approval of such substitute material will be made, until the request for the substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. Such request shall be made well in time to permit approval without delaying the work.

1.10 Frequency of Tests & Test Designation

Frequency of tests for the items of construction has been given in subsequent chapters. Test designation and procedure will be used as given in the latest version of relative publication.

1.11 Testing

Unless otherwise specified, all tests shall be performed in accordance with the methods used by AASHTO/ASTM or BS Standards and shall be made by the contractor under the supervision of the Engineer or his designated representative.

Whenever the specifications provide an option between two or more tests, the Engineer will determine the test to be used.

Whenever a reference is made in the specifications to a specification manual, or a test designation either of the American Society For Testing and Materials, the American Association of State Highway and Transportation Officials, Federal Highway Specification, or any other recognized national organization, and the number or other identification representing the year of adoption or latest revision is omitted, it shall mean the specification, manual or test designation in effect on the day 30 days prior to the date for submission of bids. Whenever said specification manual or test designation provides for test reports (such as certified mill test reports) from the manufacturer, copies of such reports, identified as to the lot of material, shall be furnished to the Engineer. When material that cannot be identified with specific test reports, proposed for use, the Engineer may, at his discretion, select random samples from the lot for testing. Test specimens from the random samples, including those required for retest,

shall be prepared in accordance with the referenced specification and furnished by the Contractor at his expense. The number of such samples and test specimens shall be entirely at the discretion of the Engineer. Unidentified metal products such as sheet plate, hardware, etc. shall be subject to the test requirements prescribed by the Engineer.

When desired by the Engineer, the Contractor shall furnish, without charge, samples of all materials entering into the work and no material shall be used prior to approval by the Engineer. Samples of material from local sources shall be taken by or in the presence of the Engineer, otherwise the samples will not be considered for testing.

1.12 Construction Stakes, Lines and Grades

The Engineer will furnish design survey data and jointly locate with contractor, all points of intersection and of tangents and basic benchmarks. The plans indicate the properties of horizontal and vertical curves, together with rates of super-elevation where required. The contractor shall set construction stakes establishing lines, slopes, and continuous profile-grade in road work, and center line and bench marks for bridge work, culvert work, protective and accessory structures and appurtenances and will furnish the Engineer with the original copy of the field notes together with all necessary information relating to lines, slopes and grades. These stakes and marks shall constitute the field control by and in accordance with which the contractor shall establish other necessary controls and perform the work.

If, in the opinion of the Engineer, modification of the line or grade is advisable, before or after stakeout, the Engineer will issue detailed instructions to the Contractor for such modification and the Contractor will revise the stakeout for further approval. No change in bid unit price will be made for such modifications.

The profiles and cross sections on the plans indicate the elevation of the top of road surface or as otherwise noted on the plans. The contractor shall be responsible for the preservation of all stakes and marks, and if any of the construction stakes or marks has been destroyed or disturbed, the Contractor will replace them at his own expense.

The Contractor shall be responsible for the accuracy of all lines, slopes, grades, and other survey work.

1.13 As-Built Drawings/Shop Drawings

During construction, the Contractor shall keep an accurate record of all deviations of work as actually installed from that shown or indicated on the Contract Drawings or revised during construction. Upon completion of the Works, the Contractor shall deliver all “As Built” drawings to the Engineer.

All shop drawings/fabrication drawings shall be prepared by the Contractor and submitted to the Engineer before the start of the work. The Engineer shall check and approve or return the same to the Contractor for correction/modification. All works are to be executed in accordance with shop drawings, approved before the commencement of the works. Shop drawings should truly reflect the provisions of typical drawings. Any deviation from the provision of contract drawings, shall not be allowed unless written approval is issued by the Engineer.

1.14 Utility Lines

The Contractor shall conduct his operations, make necessary arrangements, take suitable precautions and perform all required works incidental to the protection of and avoidance of interference with power transmission, telegraph, telephone and natural gas lines, oil lines water and sewerage mains and other utilities within the areas of his operations in connection with his contract and the Contractor shall save harmless and

indemnify the Employer in respect of all claims, demands, proceedings, costs, charges and expenses whatsoever arising out of or in relation to any such interference.

1.15 Safety Precautions.

The Contractor shall adequately provide for the safety, health and welfare of persons and for the prevention of damage to works, materials and equipment for the purpose of or in connection with the Contract.

1.16 Inspection

The Engineer shall, at all times, have safe access to the work during its construction, and shall be furnished with every reasonable facility for ascertaining that the materials and the workmanship are in accordance with the requirements and intentions of these Specifications, the Special Provisions, and the plans/drawings. All works done and all materials furnished shall be subject to inspection by Engineer.

The inspection of the work or materials shall not relieve the Contractor of any of his obligations to fulfill his contract as prescribed. Work and materials not meeting such requirements shall be made good and unsuitable work or materials may be rejected, not withstanding that such work or materials have been previously inspected by the Engineer or that payment therefor has been included in a progress estimate.

1.17 Removal of Rejected and Unauthorized Work

All works, which have been rejected, shall be remedied, or removed and replaced by the Contractor in an acceptable manner and no compensation will be allowed to him for such removal, replacement, or remedial work.

Any work done beyond the lines and grades shown on the plans or established by the Engineer, or any extra work done without written authority will be considered as unauthorized work and will not be paid for.

Upon order of the Engineer, unauthorized work shall be remedied, removed, or replaced at the Contractor's expenses.

Upon failure of the Contractor to comply promptly with any order of the Engineer made under this Item, the Employer may cause rejected or unauthorized work to be remedied, removed, or replaced and to deduct the costs from any payment due or to become due to the Contractor.

1.18 Alternative Methods of Construction

Whenever the plans or specifications provide that more than one specified methods of construction or more than one specified type of construction equipment may be used to perform portions of the work and leave the selection of the method of construction or the type of equipment to be used up to the Contractor, it is understood that the Employer does not guarantee that every such method of construction or type of equipment can be used successfully throughout all or any part of any project. It shall be the Contractor's responsibility to select and use the alternative or alternatives, which will satisfactorily perform the work under the conditions encountered.

In the event some of the alternatives are not feasible or it is necessary to use more than one of the alternatives on any project, full compensation for any additional cost involved shall be considered as included in the contract price paid for the item of work involved and no additional compensation will be allowed thereof.

1.19 Conformity with Contract Documents and Allowable Deviations.

Work and materials shall conform to the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown on the plans or indicated in these specifications. Although measurement, sampling and testing may be considered evidence as to such conformity, the Engineer shall be the sole judge, as to whether the work or materials deviate from the plans and specifications, and his decision relating to any allowable deviations therefrom shall be final.

1.20 Trial Section

Contractor shall submit complete methodology of trial section for approval of the Engineer. Trial sections shall be prepared for each type of road pavement layer. In spite of the approval of Engineer for trial section, contractor shall be responsible for the quality of work. Contractor will provide minimum of following information in the methodology.

i) Equipment to be used.
ii) Layer thickness adopted
iii) Per day production.
iv) Results of tests.

1.21 Importance of Hydrology

It is clear that any water from rain fall will flow along road or cross it at appropriate location. If proper hydrology is not conducted the quantum of water flowing along the road or crossing it and appropriate location is not estimated than the over flow of water will damage the road. Hydrology of any project depend upon the catchment area and rain fall intensity for determining the maximum quantum of water flowing along road or crossing it proper study with rain fall record of minimum 30 years are to be study to estimate the quantum of water along and cross the road.
Proper open or covered drains are designed to take care of water flowing along the road future for main water expected to cross the road Pipe Culverts, Box Culverts or Bridges are designed looking to the quantum of water expected to cross the roads the types and size of Drains, Culverts and Bridges are designed as per the requirement of the water to flow along or cross the road.

1.22 Geometry of Roads/Highways

The roads are designed with proper geometry in such a way that ruling ingredients, Degree of Curvature, Passing/Non passing side distance are kept in mind by the designer.
Ruling ingredients should not be more than standard fixed by various organizations. However briefly speaking these ruling ingredients are varying between 3% to 7% for all types of vehicles, any gradients less than 3% is essential for a Motor way/Express way.
Road curvatures are also important features for the design of the road for sharp curves spiral road design road design must be added on both end of the circular curve, the provided a comfortable driving standards fixed by various organization must be followed by the designer for provide the reasonable geometry of the road, keeping in consideration the economy of the project.
The vertical alignments of roads also depend on various hydraulic structures to be designed on the alignment. It is recommended that proper software is used to design the geometry of the road.

2. Scope

The Standard Specifications is a part of contract documents, which shall be read in conjunction with the following contract documents, which are mutually explanatory to one another and mentioned hereunder, with the order of precedence as given in the Conditions of Contract.

(i) Contract Agreement
(ii) Instruction to bidders
(iii) Addenda
(iv) Letter of acceptance
(v) Supplementary Conditions of Contract
(vi) Special Provisions
(vii) Conditions of Contract Part - II
(viii) Conditions of Contract Part - I
(ix) Tender Drawings
(x) Bill of Quantities
(x) General Specifications
(xi) The bid and Appendices "A to L"

3. Abbreviations and Definitions

Wherever in these specifications or in other contract documents the following abbreviations and terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

3.1 Abbreviations

AASHTO	-	American Association of State Highway and Transportation Officials. (USA)
ASTM	-	American Society for Testing and Materials
AWG	-	American Wire Gauge
AWPA	-	American Wood Preservers Association
BS	-	British Standard Code of Practice
ACI	-	American Concrete Institute (USA)
FHWA	-	Federal Highway Administration (USA)
PCA	-	Portland Cement Association (USA)
ISSA	-	International Slurry Surfacing Association (USA)
NRMCA	-	National Ready Mix Concrete Association (USA)
Wt.	-	Weight
HMA	-	Hot Mix Asphalt
RAP	-	Reclaimed Asphalt Pavement
Lb.	-	Pound
AWS	-	American Welding Society
Gallon	-	U.S. Gallon
In.	-	Inch
Ft.	-	Foot
Yd.	-	Yard
Ltr.	-	Litre
mm	-	Millimeter
cm.	-	Centimeter
M	-	Meter
Km	-	Kilometer

SM	-	Square Meter
o	-	degree
Sq. cm.	-	Square Centimeter
CM	-	Cubic Meter
ha	-	Hectare
Kg	-	Kilogram
Ton	-	Metric Ton (1000 Kg)
^{o}C	-	Degree Centigrade
^{o}F	-	Degree Fahrenheit

3.2 Definitions

Wherever in these specifications or in other contract document the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

Accepted

– Completion of the work item to the Engineer's satisfaction

Addendum

–- A written amendment or revision to the Contract documents or plans issued to bidders prior to the final date and time for submission of Tenders in the "Instruction to Tenderer."

Aggregates

– Crushed stone or processed gravel (shingle)

Amenities

– Recreational facilities and similar items provided to improve living conditions at site - characteristics conducive to pleasantness.

Apron

– A concrete, rock or masonry slab forming a part, or for the protection of a structure.

Asphalt Base Course

– The lowermost layer of specified thickness of an asphalt concrete pavement which may include an asphalt leveling course.

Asphalt Concrete

– High quality, thoroughly controlled hot mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted into a uniform, dense mass.

Asphalt Concrete Pavement

– All courses of asphalt-aggregate mixtures placed above the layer of base course, subbase or improved subgrade. When placed directly on the subgrade, it is called full-depth asphalt pavement.

Auxiliary Lane

– That portion of the roadway adjoining the traveled way for speed change or other purposes supplementary to through traffic movements.

Barrage

– A low dam or weir across a river equipped with a series of gates to regulate the water surface level above the weir.

Base Course

– The layer of specified material and thickness placed immediately below the surfacing.

Batten

– Beam, structural member.

Beldar

– Unskilled labour employed on maintenance gangs for canals or roads.

Bid/Tender Price

– The sum of the products of the quantities of work with the quoted prices in the Tender by the Contractor.

Bill of Quantities and list of Prices

– A list showing work quantities and specifying unit price and/or lump sum for specific items of work.

Blinding Layer

– A layer of concrete or other material (Generally thin) covering the surface of excavated ground or fill, forming a stable surface on which further work may be constructed.

Boulder

– A rock fragment, usually rounded by weathering or abrasion, with a size of 525 cubic cm or more.

Boundary

– Limit of Right-of-Way (ROW) or other zones.

Bridge

– Any structure other than a culvert, which carries a utility, facility, or railroad highway, pedestrian, or other traffic over a water course, over, under or around any obstruction and with a clear span of more than 6.50 M.

Bund

– A continuous embankment, dike or levee (generally associated with training or containing the flow of rivers).

Catchment

– The watershed or area which contributes runoff to a drain or other channel.

Contractor

– The individual firm or corporation contracting with the Employer/Client for performance of the prescribed work.

Contract Price

– The sum of the products of the quantities with the agreed prices appearing in the agreement between the Contractor and the Engineer/Employer.

Construction Limit

– Construction limit of a project is area between left & right side of catch points of road under construction, where as in case of structures this limit will extend to area which is required for execution of permanent structure

Cubic Meter

– A volume equivalent to 1.0 M x 1.0 M x 1.0 M.

Cuboid

– Crushed stone particles with each face fractured and in roughly cuboid shape.

Culvert

– Any structure, other than a bridge which provides an opening under a roadway for drainage or irrigation purpose and with a clear span of 6.5 M or less.

Cum

– With or associated with - for example, 'Railroad-cum-road' bridge.

Cusec

– A rate of flow of one cubic foot per second.

Daywork

– Work to be paid for on the basis of actual labour, material, and plant used - Force account.

Detour (Diversion)

– A temporary roadway, which leaves the main, route and rejoin it later, for the uninterrupted flow of traffic.

Drawings

– The approved plans(drawings), profiles, typical cross-sections, revised drawings and supplemental drawings, or exact reproduction thereof, which show the location, character, dimensions and details of the work.

Earth

– Sediments or other unconsolidated accumulations of solid particles, produced by the physical and chemical disintegration of rock, and which may or may not contain organic matter.

Engineer

– The duly authorized representative of the Client/Employer for controlling the project site, acting directly or through his duly authorized representatives, who is responsible for engineering supervision of the work.

Equipment

– All machinery and equipment, together with the necessary supplies for up keep and maintenance and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

Fix

– Any item of construction which requires special placement in the works.

Flexible Pavement Structure

– Any combination of improved subgrade, subbase, base and asphalt surfacing placed on the subgrade to support the traffic load and reduce its intensity at the subgrade surface.

Forms or Formwork

– Shuttering including supports and falsework.

Frustration of a Contract

– Rendered impossible of performance by external cause beyond the contemplation of the parties.

Gang Header

– Experienced workman or labour incharge of small groups of workmen or labour.

Gasoline

– Motor spirit, petrol.

Godown

– Warehouse, store room or storage shed.

Grade

– The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal center-line of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.

Gravel

– Small sized stone, shingle or rock fragments usually rounded in shape formed from rocks or boulders by glacial or weathering action..

Guide Bank (for Bund)

– A protective and training embankment or levee for directing river flow.

Highway

– A general term denoting public way for purposes of vehicular travel, including the entire area within the right-of-way. (Recommended Usage: in urban areas-highway or street; in rural areas-highway or road).

Install

– To place in special position any hardware, equipment or fixture for completing a job.

Kilometer

– A distance equal to 1000 meters.

Laboratory

– A testing laboratory approved by NHA or any testing laboratory, which may be designated by the Engineer.

Leveling Course

– The layer of specified material of variable thickness placed generally on an existing road surface to compensate for depressions and undulations in order to correct grades and cross falls according to design.

Materials

– Any substance specified for use in the construction of the project and its appurtenances.

Metalled (roadway)

– Surfaced, paved (roadway).

Mile

– Distance of 5,280 feet. (1,610 M)

Monsoon

– Prevailing winds in the Indian Ocean.

– The rainy season associated with the south-west monsoon.

Motor Spirit

– Petrol, gasoline.

Octroi

– A municipal fee for municipal services.

Period of Maintenance

– Period of maintenance shall mean the period of contractor's maintenance named in the contract, calculated from the date of completion of the work as certified by the Hand-over committee.

Pitching or Rip-Rap

– Broken stone, brickwork or other materials placed usually on side slopes of Embankments for protection of the earth surface, dry or in cement mortar as specified.

Prime Cost

– A net sum entered in the Bill of Quantities by the employer as the sum provided to cover the cost of or to be paid by the Contractor to merchants or others for specific articles or materials to be supplied after deducting all trade discounts and any discount for cash.

Provide

– To make available an item for a certain period/time or indefinite time as the case may be.

Provisional Sum

– Any sum of money fixed by the Employer and included in the Bill of Quantities to provide for work not otherwise included therein. A provisional sum is only to be expended, either wholly or in part under the Employer's Representatives or the Engineer's direction in accordance with Contract. This sum may or may not be utilised in full or partially through the contractor.

Regulator

– A canal structure, usually equipped with gates, for control, or checking, of flow in the canal or an off taking channel.

Return

– Report

Revetment (Material)

– Rock.

Right-of-way (ROW)

– A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes.

Roadside

– A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadway

– The portion of a highway within limits of construction.

Scaffolding

– Arrangement of struts/columns/pipes to support shuttering or other platforms.

Setting out

– Laying out or staking out-establishing on the site the lines, levels and grades to which the construction works are to be carried out.

Shingle

– See Aggregates.

Shoulders

– The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Sidewalk

– That portion of the roadway primarily constructed for the use of pedestrians.

Sleepers

– Cross ties, railroad ties.

Soil Binder

– Portion of Soil passing 0.425 mm (# 40) sieve.

Special Provisions

– Additions and revisions to the Standard Specifications and General Conditions of Contract, covering conditions particular to an individual contract.

Spoil Bank

– Disposal area for excess excavation, spoil tip or waste dump.

Structures

– Bridges, culverts, catch basins, drop inlets retaining walls, manholes, headwalls, service pipes causeways Irish bridges and other features which may be encountered in the work and not otherwise classed herein.

Subbase

– The layer of specified material and thickness placed between the base course and subgrade.

Subgrade

– The top surface of a roadbed upon which the pavement structures and shoulders including curbs are constructed.

Subgrade level

–That level of the roadbed (or, embankment) on which other road material has to be placed.

Subgrade treatment

– Modification of roadbed material by stabilization.

Substructure

–All of that part of a structure below the bearings of simple and continuous spans, or rigid frames, including back walls, wing walls.

Super-tax

–A Pakistani tax on income or profit above a certain level of income or profit.

Surface Course

–The uppermost layer of specified thickness of an asphalt concrete pavement; also called "Wearing Course".

Surfacing

–The uppermost layer of specified material placed on the traveled way or shoulder. Types of surfacing may consist of surface treatment (hot surface dressing) of asphalt concrete surface course, or concrete pavement.

Supply

–Primarily meaning to deliver any item on permanent basis.

Tender

–Bid proposal.

Tenderer

–A firm or individual submitting a Tender.

Traffic Lanes

– That portion of a traveled way allowing the movement of a single line of vehicles.

Unmetalled (Roadway)

– Unsurfaced, unpaved (roadway)/dirt road.

Variation Order

– A document compiled to include changes, substitutions and additional work items not covered in the B.O.Q, for the sanction of the competent Authority and shall include increase or decrease in quantities or rates also.

Work

– The work shall mean the furnishing of all labour, materials, equipment and other incidentals necessary or convenient to the successful completion of the project and carrying out of all the duties and obligations imposed by the contract.

Wagon (railway)

– A railroad freight car.

Wayleave

– Permission to cross land, right of entry as defined in the land acquisition act of the Government of Pakistan.

Well

– A concrete or masonry caisson incorporated in foundations.

Working Drawings

– Stress sheets, shop drawings, erection plans, falsework plans, form work plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data which the contractor is required to submit to the Engineer for approval.

Written Undertaking

– A written promise.

TABLES FOR SAMPLING
AND
TESTING FREQUENCIES

SCHEDULE FOR SAMPLING AND TESTING OF EMBANKMENT AND SUBGRADE (ITEM NO. 104 TO 113)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Soil	Classification.	AASHTO M-145	1/2,000 CM.	As per Item 108.2, 109.2.5, 110.2 etc.
	CBR	AASHTO T-193	1/2,000 M.	Existing Natural Ground.
	CBR	AASHTO T-193	1/2,000 CM.	As per Item 108.2 and 110.2 etc.
	Swelling	AASHTO T-193	1/2,000 CM.	As per Item 108.2 (c)
	Moisture Density (Lab) or	AASHTO T-180	1/2,000 CM.	As per Item 108.3,
	Relative Density.	ASTM D-4254-83	1/1,000 CM.	109.2.2 etc ref. Density
	Field Density.	AASHTO T-191	1/200 M. per Lane	As per Item 104.2, 108.3, 109.2.2 etc.

SCHEDULE FOR SAMPLING AND TESTING OF GRANULAR SUBBASE (ITEM NO. 201)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3/Source plus 1/1000 CM	As per Item No. 201.2
	Plasticity Index.	AASHTO T-89 and T-90	3/Source plus as required based on visual observation.	- do -
	CBR	AASHTO T-193	3/Source plus as required based on variation in gradation or 1/1000 CM	- do -
	Abrasion	AASHTO T-96	3/Source plus 1/500 CM	- do -
	Moisture Density.	AASHTO T-180	1/1000 CM	- do -
	Field Density	AASHTO T-191, T-238 and T-239	4/layer/400 M laid 3 Minimum/layer if less than 400 M laid.	As per Item No. 201.3.4.
	Sand Equivalent	AASHTO T-176	3/source plus as required based on visual observation.	As per Item No. 201.2

SCHEDULE FOR SAMPLING AND TESTING OF AGGREGATE BASE COURSE (ITEM NO. 202)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3/Source plus 1/1000 CM	As per Item 202.2 (a)
	Plasticity Index.	AASHTO T-89 and T-90	3/Source plus as required based on visual observation.	As per Item 202.2 (e)
	CBR	AASHTO T-193	3/Source/stock pile plus as required based on variation in gradation.	As per Item 202.2 (f)
	Abrasion	AASHTO T-96	3/Source plus 1/5,000 CM	As per Item 202.2 (c)
	Sodium Sulphate Soundness	AASHTO T-104	3/Source plus 1/5,000 CM	As per Item 202.2 (d)
	Fractured faces.	Visual	3/Source plus as required based on visual observation.	As per Item 202.2 (b)
	Moisture Density.	AASHTO T-180	1/1000 CM	As per Item 203.3.3.
	Field Density.	AASHTO T-191 or T-238 and T-239.	4/layer/400 M laid 3 minimum/layer if less than 400 M laid.	As per item 202.3.3.
	Sand Equivalent	AASHTO T-176	3/source plus as required based on visual observation.	As per Item 202.2(e)

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency.	Reference
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	
	Abrasion	AASHTO T-96	3/Source/stock pile plus 1/5000 CM	As per Item 203.2.1 (a)
	Sodium Sulphate Soundness	AASHTO T-104	3/Source plus 1/5000 CM	As per Item 203.2.1 (b)
	Stripping	AASHTO T-182	3/Source plus 2/5000 CM	--
	Fractured faces	Visual	3/Source plus as required based on visual observation.	As per Item 203.2.1
	Flat and Elongated Particle.	Visual	" " "	As per Item 203.2.1 (e)
	Specific Gravity. and Absorption	AASHTO T-85	4/Source for each size in Hot bins of Asphalt Plant	For use in preparation of JMF.
Fine Aggregate	Sand Equivalent or	AASHTO T-176	3/Source plus as required based on visual observation.	As per Item 203.2.1 (c)
	Plasticity Index.	AASHTO T-89 and T-90.	2/1000 CM	As per Item 203.2.1 (d)
	Specific Gravity.	AASHTO T-84	4/Source.	For use in preparation of JMF.
	Friable Particles	AASHTO T-112	2/5000 CM	--
Asphalt Cement.	Specific Gravity.	AASHTO T-228	2/Shipment.	For use in preparation of JMF.
	Penetration.	AASHTO T-49	3/Week of plant operation Samples taken from heating tank at staggered intervals.	As per Item 203.2.2.
Mixture	Extraction	AASHTO T-164		
	Gradation	T-30		
	Bulk Sp. Gr.	AASHTO T-166 Method B		
	Maximum Sp. Gr.	AASHTO T-209	2/day's production.	As per Item 203.2.3.
	Air Voids	AASHTO T-269		

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency.	Reference
Mixture Compacted in place.	Thickness	AASHTO T-230	1/layer @ 100 M interval per lane.	As per item 203.3.11.
	Compaction	AASHTO T-230 ASTM D2950	1/layer @ 100 M interval per lane.	As per item 203.3.9

Notes: Test locations will be selected at random.

SCHEDULE FOR SAMPLING AND TESTING OF SOIL-CEMENT BASE COURSE (ITEM NO. 204)

Material	Test	Designation	Sampling and Testing Frequency.	Reference
Soil	Classification.	AASHTO T-27 and T-89.	3/Borrow Source plus 1/1000 CM	Soil Class must be A-3 or A-4.
Mixture	Moisture- Density.	AASHTO T-134	1/Soil Class.	As per Item 204.3.4 for ref. Density
	Pulverization.	Note (a)	1/300 m strip	–
	Field Density.	AASHTO T-191 or T-238 & T-205.	1/300 m strip 1/300 m strip	As per Item 204.3.5.
	Compressive Strength	ASTM D-1633	1/Soil Class	As per Item 204.2.4
	Wetting & Drying	AASHTO T-135	1/Soil Class	For mix design.

Note: a) Screening of Soil through one inch and No. 4. sieves prior to mixing with cement.

SCHEDULE FOR SAMPLING AND TESTING OF CRACK-RELIEF LAYER (ITEM NO. 205)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate (Crushed)	Gradation	AASHTO T-27	Same as for item 202.	As per Item 205.2.1.
Aggregate (Asphaltic open-graded plant mix)	Gradation	AASHTO T-27	Same as for coarse aggregate under item 203.	As per item 205.2.1.
Asphalt Cement	–	–	Same as for Item 203.	As per Item 203.2.2.
Mixture	Asphalt Coating.	AASHTO T-195	1/day's production or as required based on visual observation.	–

SCHEDULE FOR SAMPLING AND TESTING OF WEARING COURSE PLANT MIX (ITEM NO. 305)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	
	Abrasion.	AASHTO T-96	3/Source plus 1/5000 CM	As per Item 305.2.1 (a)
	Sodium Sulphate Soundness	AASHTO T-104	3/Source plus 1/5000 CM	As per Item 305.2.1 (b)
	Stripping	AASHTO T-182	3/Source plus 1/5000 CM	
	Fractured faces	Visual	3/Source plus as required base on visual observation.	As per Item 305.2.1
	Flat and Elongated Particle.	Visual	- do -	As per Item 305.2.1 (e)
	Specific Gravity and Absorption.	AASHTO T-85	4/Source for each size in Hot bins of Asphalt Plant.	For use in preparation of JMF.
Fine Aggregate	Sand Equivalent or	AASHTO T-176	3/Source plus as required base on visual observation.	As per Item 305.2.1 (c)
	Plasticity Index.	AASHTO T-89 & T-90.	1/1000 CM	As per Item 305.2.1 (d)
	Specific Gravity.	AASHTO T-84	2/Source	For use in preparation of JMF.
	Friable Particles	AASHTO T-112	1/5000 CM	–
Asphalt Cement.	Specific Gravity.	AASHTO T-228	2/shipment.	For use in preparation of JMF.
	Penetration.	AASHTO T-49	3/week of plant operation. Samples taken from heating tank at staggered intervals.	As per clause 305.2.2
Premix Asphalt	Extraction	AASHTO T-164		
	Gradation	AASHTO T-30		
	Flow	AASHTO T-245		
	Stability	AASHTO T-245	2/day's production.	As per Clause 305.2.3.
	Bulk Sp. Gravity	AASHTO T-166		
	Loss Stability	AASHTO T-245		

SCHEDULE FOR SAMPLING AND TESTING OF WEARING COURSE PLANT MIX (ITEM NO. 305)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Mixture compacted in place.	Thickness	AASHTO T-230	1/layer @ 100 M interval per lane.	As per item 305.3.2.
	Compaction	AASHTO T-230 ASTM D2950	1/layer @ 100 M interval per lane.	As per Item 305.3.2.

Notes: Test locations will be selected at random.

SCHEDULE FOR SAMPLING AND TESTING OF HOT MIX ASPHALT RECYCLING (ITEM NO. 308.2)

In addition to the tests specified under Items 203 or 305 following tests shall be conducted for Hot Mix Recycling of Asphalt.

Material	Test	Designation	Frequency [1]
Aggregate	Stockpile gradation	AASHTO T-27	1 per day
	Cold feed gradation		1 per day
	Hot bin gradation (if applicable)		1 per day
RAP	RAP composition (asphalt content and gradation)	AASHTO T-27 & AASHTO T-164	1 per 500 M per lane (more if RAP is very variable)
	Viscosity of Asphalt recovered from RAP	AASHTO T-202	1 per 500 M per lane (more if RAP is very variable)
Recycled Asphalt Mix	Asphalt Mix Temperature		Regularly throughout the day
	Viscosity of Asphalt recovered from Recycled Mix	AASHTO T-202	1 per day or 1 per 500 Tons of HMA
	Extracted asphalt content and gradation	AASHTO T-27 & AASHTO T-164	2 per day

SCHEDULE FOR SAMPLING AND TESTING OF HOT IN-PLACE ASPHALT RECYCLING (ITEM NO. 308.3)

In addition to the tests specified under Item 305 following tests shall be conducted for Hot In-Place Recycling of Asphalt.

Material	Test	Designation	Frequency [1]
New Aggregates	Gradation	AASHTO T-27	1 per day
Existing Asphaltic Pavement	Composition (asphalt content and gradation)	AASHTO T-27 & AASHTO T-164	2 per sub-project or 1 per 1000 M per lane These tests shall be conducted prior to start of work at site.
Scarified Asphalt	Composition (asphalt content and gradation)	AASHTO T-27 & AASHTO T-308 / T-164	1 per day or 1 per 250 M per lane
	Viscosity of Asphalt	AASHTO T-202	1 per day or 1 per 500 M per lane
Recycled Asphalt Mix	Asphalt Mix Temperature behind laydown machine		Regularly throughout the day
	Viscosity of Asphalt recovered from Recycled Mix	AASHTO T-202	2 per day
	Asphalt content and gradation	AASHTO T-27 & AASHTO T-308 / T-164	2 per day

1 If two or more frequencies of tests are given, the frequency which leads to more tests shall be followed.

Note:
Due to unpredictable nature of Recycling work, the Engineer shall be authorized to increase the frequency of tests as required by site conditions and proper execution of work.

SCHEDULE FOR SAMPLING AND TESTING OF COLD IN-PLACE / FULL DEPTH RECYCLING (ITEM NO. 308.4 & 308.5) [1]

Type of Testing	Purpose of Testing	Frequency	Sample Location and Size
Recommended for Control and Testing			
RAP gradation.	Specification compliance with maximum RAP size determined	Each 0.8 km [1,6]	From conveyor belts, windrows or mat, minimum weight of 9.1kg [2]
Asphalt emulsion, recycling agent, Portland cement, fly ash, and lime	Check on specification compliance	Every load sampled, one test per day	From asphalt tank on recycling unit or transport truck, wide-mouth plastic bottle, 1 Lit. sample size [3]
Moisture added to RAP [4]	Adjustment of water content for proper mixing and compaction	Each 0.8 km [1,6]	From belt into mixer or after spreading, minimum weight of 9.1 kg [2]
Mat moisture content after curing (emulsions/recycling agents only)	To determine when the new asphalt surface can be placed	Each 0.8 km, one each lane [1,6]	Full lift depth sample, minimum weight of 1.4 kg [2]
Recycling additive content	Verify amount of recycling additive and also accuracy of meter readings	Minimum of one per day	By tank gauging, transport truck weighing or meter readings and RAP weight by belt scale readings
Recycled material compacted density by rolling control strips [5]	To establish rolling procedures and target density for specification compliance	Minimum of two strips and nuclear density testing each 0.8 km [1,6]	Strips at beginning of project and additional if major changes in recycled mixture properties occur, 120 to 150 m length
Or			
Recycled material compacted density by field compacted specimens [5]	To establish the target for specification compliance	Material sample and nuclear density testing each 0.8 km [1,6]	Material sampled from windrow or mat after spreading, minimum weight of 9.1 kg [2]
Depth of pulverization/milling	For specification or plan compliance	Each 0.2 km or additional as needed	Measurements across the mat, adjacent to longitudinal joints and at the outside edge
Recommended for Control and Testing			
Spreading depth of recycled material, central plant cold recycling only	Check of the lift thickness for specification or plan compliance	Each 0.2 km or additional as needed	Measurements across the mat, adjacent to longitudinal joint and at the outside edge
Mixing equipment calibration	To assure proper content of the recycling additive and moisture	Prior to beginning of work each year and additional as needed [7]	Material being recycled from mixer into a truck and liquids into barrels, tanker or asphalt distributor for weighing by a scale

Table Item No. 308.4 Continued.

Type of Testing	Purpose of Testing	Frequency	Sample Location and Size
For Information Only			
Recycled material temperature	To determine the influence of temperature on compaction and temperatures for mix design	Minimum of four each day, two early morning and two late afternoon	Determined for the recycled material when mixing and the mat immediately prior to the beginning of compaction
Recycled mat smoothness	To develop data on spreading and for possible future specification requirements	Continuously or at selected locations of existing pavement and after cold recycling	By profilograph device (California or other) or straight edge
Original pavement and recycled material asphalt contents (by solvent extraction) [8]	To determine added and total asphalt contents	Randomly [6]	From selected locations in a stockpile or pavement before recycling and in the recycled mat, minimum weight of 9.1kg [2]

Notes:

1 Additional sampling and testing may be required if major changes in RAP characteristics are observed, such as a much coarser or finer gradation or noticeable differences in asphalt content, or when considerable variability is occurring in field test results.

2 It is recommended that RAP sampling generally should be in accordance with the ASTM D 979 or AASHTO T 168 procedures for Sampling Bituminous Paving Mixtures.

3 Asphalt emulsion and asphalt recycling agent sampling should be in accordance with ASTM D 140 or AASHTO T 40 for Sampling Bituminous Materials.

4 The moisture content can be determined with ASTM D 1461 or AASHTO T 110 for Moisture or Volatile Distillates in Bituminous Paving Mixtures. Also, the moisture content appears can be determined adequately by weighing and drying to a constant weight using a forced draft oven as for ASTM D 2216 or AASHTO T 265 or by microwave oven drying as for ASTM D 4643.

5 Target densities for recycled mix compaction are being established by using rolling control strips or by the field compaction of density specimens using Marshall, Proctor or gyratory compactors. The compacted density, when determined, is measured with a nuclear density/moisture gauge since it is generally not possible to obtain cores during construction. For control strips, backscatter is typically used but for density checks for specification compliance, direct transmission measurements are preferred. The procedures generally followed are in accordance with ASTM D-2950 for the Density of Bituminous Concrete in Place by Nuclear Methods. The density obtained will be a “wet density” as conversion to a true “dry density” by the gauge is not possible with these types of mixes. A reasonably accurate dry density may be obtained by sampling the recycled mix at the nuclear gauge test location, determining the moisture content by drying and correcting the gauge wet density.

6 For each length or lot size quantity specified, materials sampling may be completed on a random basis using the procedures of ASTM D 3665 for Random Sampling of Construction Materials.

7 Based on the mixer computer meter readings and other checks, additional calibration may be required. This calibration may require only checking and adjusting the best scale system using weights.

8 The asphalt content in the cold recycled mixture can be determined by one of the following asphalt extraction testing methods: ASTM D 2172, ASTM D 4125, AASHTO T 164, or AASHTO T 287.

QUALITY CONTROL PROCEDURES FOR SUPERPAVE ASPHALT CONCRETE MIXES (ITEM 314)

Work	Properties	Testing method	Location of Sampling	Sampling frequency	Reference
Asphalt binder	Quality requirements and PG classification	Tests indicated in Table 314-2	At Source	One test In the beginning of supply during the mix design and whenever the source or mix properties are changed.	Table 314-4
Aggregate	Consensus properties	Tests indicated in Table 314-7		3 tests on different samples from each source at source approval and design job mix formula or when source is changed or when noticing a change in constructed works properties, and 5 tests on different randomly time selected samples for each 5000 cubic meters from each source during construction	Table 314-5
	Source Properties	Tests indicated in Table 314-6			Table 314-6
	Specific gravity (G_{sb}) and absorption	AASHTO T-19		3 samples during mix design and one test for each week or when mix properties are changed	Section 314.2.2
Material during Construction	Aggregate gradation (dry mix)	AASHTO T-27	At Stock Piles	3 samples during mix design and one test for each week or when mix properties are changed.	Tables from 314-9 to 314-14
	Specific gravity (G_{sb}) and absorption	AASHTO T-19		3 samples during mix design and one test for each for each week or when mix properties are changed.	Section 314.2.2
	Source properties	Tests indicated in Table 314-6		One test each month or when mix properties are changed	Table 314-6
	Consensus properties	Tests indicated in Table 314-7		One test each month or when mix properties are changed.	Table 314-5
Asphalt mix test	Aggregate gradation and asphalt content	AASHTO T-27 / T-164 T-308 / T-310		At least one samples for each for each 500 cubic meters or one for each daily production from each constructed layer	Table 314-19
	Volumetric properties using Gyratory compaction at design number of Gyrations (N_{des})	AASHTO T-315		At least three tests at approval of design aggregate structure or when properties or mix aggregate are changed and one test for each 500 cubic meters from each Plant or for each working day which is the lesser.	Table 314-19
	Percent of max density G_{mm} using Gyratory compaction at maxinum number of Gyrations (N_{max})	AASHTO T-312		One Test for every four production days or one test for each 500 cubic meters from each Plant which is the less	Table 314-19
	Maximum theoretical specific gravity	AASHTO T-209		At least three tests at approval of design aggregate structure or when properties or mix aggregate are changed and one test for each 500 cubic meters from each Plant or for each working day which is the lesser.	Table 314-19
	Mixture sensitivity to moisture induced damage	AASHTO T-283		One test when design and approval of job mix formula or when the mix properties are changed.	Item 314.2.3.1

QUALITY CONTROL PROCEDURES FOR SUPERPAVE ASPHALT CONCRETE MIXES (ITEM 314)

Constructed Works	Compaction	AASHTO T-310	At Site	One test for each 1000 square meters from each constructed layer or working day which is the lesser.
	Thickness	ASTM D-3549		One test from each 1000 square meters from each constructed layer or working day which is the lesser.
	Skid resistance on surface layer	Skid resistance measurement		Skid measurements for each working day
	Surface layer roughness	Road roughness measurement		Using measurement methods indicated in special specifications for each working day.
	Levels, dimensions and, slopes measurements	Contract Documents		Cross Section measurements each 25 meters or 5 sections each 1000 square meters whichever is greater.

SCHEDULE FOR SAMPLING AND TESTING OF CONCRETE
(ITEM NO. 401)

Material	Test	Designation	Sampling and Testing Frequency	Acceptance Limit.
Coarse Aggregate	Gradation	AASHTO T-27	2/Stockpile plus 1/1000 CM	As per Item 401.2.3
	Unit Wt.	AASHTO T-19	1/Source plus 1/1000 CM	For use in preparation of mix design.
	Sp. Gravity	AASHTO T-85	2/Source plus 1/1000 CM	- do -
	Absorption	AASHTO T-85	1/Source plus 1/500 CM	- do -
	Abrasion	AASHTO T-96	1/Source plus 1/5000 CM	As per Item 401.2.3
	Soundness	AASHTO T-104	1/Source plus 1/5000 CM	As per Item 401.2.3
	Deleterious Substance	AASHTO M-80	1/Source plus 1/5000 CM	As per Item 401.2.3
Fine Aggregate	Gradation	AASHTO M-6	2/Source plus 1/1000 CM	As per Item 401.2.2
	Unit Wt.	AASHTO T-19	4/Source plus 1/800 CM	For use in preparation of mix design.
	Specific Gravity	AASHTO T-84	4/Source plus 1/1000 CM	- do -
	Absorption	AASHTO T-84	1/Source plus 1/1000 CM	- do -
	Organic Impurities	AASHTO T-21	1/Source plus 1/1000 CM	As per Item 401.3.9 and 401.2.2
	Soundness	AASHTO T-104	1/Source plus 1/5000 CM	–
	Fineness	AASHTO M-6	1/Source plus 1/1000 CM	As per Item 401.2.2
	Deleterious Substance	AASHTO M-6	1/Source plus 1/5000 CM	As per Item 401.2.2
	Petrographic	–	1/Source plus 1/5000 CM	–

SCHEDULE FOR SAMPLING AND TESTING OF CONCRETE (ITEM NO. 401)

Material	Test	Designation	Sampling and Testing Frequency.	Acceptance Limit.
	Yield Test for Cement Content	AASHTO T-121	1/Lot or 1000 Bags	As per Item 310.3.3
Cement	Setting Time	AASHTO T-131	1/Lot or 1000 Bags	As per Item 401.2.1
	Mortar Strength	AASHTO T-132	1/Lot or 1000 Bags	As per Item 401.2.1
Water	Chemical Tests	AASHTO T-26	1/Source	As per Item 401.2.7
Concrete mix	Compression (Cube or Cylinder)	AASHTO T-22	6/Shift or 50 CM (2 sets of 3 each)	As per Item 401.1.1 table 401-1
	Slump	AASHTO T-119	2/shift or 50 CM	- do -

SCHEDULE FOR SAMPLING AND TESTING OF HIGH PERFORMANCE CONCRETE (ITEM NO. 414) REQUIREMENTS SUPPLEMENTARY TO THAT FOR ITEM 401

Material	Test	Designation	Sampling and Testing Frequency.	Acceptance Limit.
Aggregates at Batching Plant	Gradation	ASTM C-136	1/shift	As per Item 414.2
	Finer than No. 200 sieve	ASTM C-117	1/shift	- do -
	Moisture Content	ASTM C-566	1/shift	- do -
Concrete mix	Compression (Cylinder)	ASTM C-39	6/shift or 50 CM (2 sets of 3 each)	As per Table 414-6
	Slump	ASTM C-143	2/shift or 38 CM	- do -
	Air Content	ASTM C-231	2/shift or 38 CM	- do -
	Density	ASTM C-138	2/shift or 38 CM	As per Item 414.2.6.2
	Temperature	ASTM C-1064	2/shift or 38 CM	As per Item 414.3.2

TABLE FOR ALLOWABLE TOLERANCES
(EARTHWORKS, PAVEMENT COURSES AND CONCRETE)

Description	Thickness (mm)	Level (mm)	5M Straight-edge (mm)	Cross-fall (%)	Longitudinal Grade in 30 M (%)
Sub-grade	± 20	+ 0 - 40	30	± 0.5	± 0.1
Subbase (Granular or Stabilized)	+ 10 - 20	+ 0 - 25	20	± 0.3	± 0.1
Base Course (Granular or Stabilized)	+ 5 - 10	+ 5 - 10	6	± 0.2	± 0.1
Asphaltic Base Course.	+ 3 - 10	+ 3 - 10	6	± 0.2	± 0.1
Asphaltic Wearing Course.	± 3	± 3	5	± 0.2	± 0.1
Concrete for Pavements.	+ 10 - 5	+ 10 - 5	5	± 0.2	± 0.1
Concrete for structures	± 5	± 10	5	- -	- -

Note:

1. Material for stabilization of soil may be cement, lime or bitumen.
2. Accumulative tolerance shall not be more than that as specified against the final layer.

ALLOWABLE TOLERANCE FROM THEORETICAL WEIGHTS (REINFORCEMENT) AS PER AASHTO M-31

Diameter of Bars	* Lot under	Individual Bar under
All	3.5 %	6%

* The term “Lot” means all bars of the same nominal weight per linear meter contained in an individual shipping release or shipping order.

Note: Reinforcing bars are evaluated on the basis of nominal weights. In no case shall the overweight of any bar or lot of bars be cause of rejection.

TABLE FOR ALLOWABLE TOLERANCE
(REINFORCED CONCRETE PIPES OF CLASS - II AND IV)
AS PER AASHTO M-170

Description	Internal diameter variation (%)	Wall Thickness	Permissible Variation in the Position of Reinforcement
Pipes of internal diameter of 300 mm to 610 mm	$\pm$ 1.5	- 5 mm or - 5 percent Whichever is less	$\pm$ 10 percent of wall thickness or $\pm$ 12 mm. whichever is less
Pipes of internal diameter of 690 mm to 2750 mm	$\pm$ 1.0	- 5 mm or - 5 percent Whichever is less	$\pm$ 10 percent of wall thickness or $\pm$ 12 mm. whichever is less

Notes:

1. Pipe having localized variations in wall thickness exceeding those specified above shall be accepted, if the three-edge bearing strength and minimum steel cover requirements are met.

2. Pipes having variations in the position of the reinforcement exceeding those specified above shall be accepted if the three-edge bearing strength requirements on a representative sample are met.

SECTION-I

EARTH WORK AND ALLIED ACTIVITIES

Item No		Description	New Construction	Rehabilitation	Maintenance
100	-	General, Earth Work.	o	o	o
101	-	Clearing and Grubbing.	o		
102	-	Removal of Trees.	o		
103	-	Stripping.	o		
104	-	Compaction of Natural Ground.	o		
105	-	Roadway and Borrow Excavation.	o		
106	-	Excavation of Unsuitable surplus material.	o		
107	-	Structural Excavation and Backfill.	o	o	
108	-	Formation of Embankment.	o	o	o
109	-	Subgrade Preparation.	o	o	
110	-	Improved Subgrade.	o		
111	-	Soil Cement Stabilized Subgrade.	o		
112	-	Lime Stabilized Subgrade.	o		
113	-	Bitumen Stabilized Subgrade.	o		
114	-	Dressing and Compaction of Berms.		o	o
115	-	Reinstatement of shoulders from Brick Kiln material.		o	o

SECTION-II

SUBBASE AND BASE.

Item No	Description	New Construction	Rehabilitation	Maintenance
200 -	General.	o	o	o
201 -	Granular Subbase.	o	o	o
202 -	Aggregate Base Course.	o	o	o
203	Asphaltic Base Course Plant Mix.	o	o	
204 -	Soil Cement Stabilized Subbase and Base.	o	o	
205 -	Crack Relief layer.		o	o
206 -	Water Bound Macadam Base.	o	o	o
207 -	Deep Patching.		o	o
208 -	Reinstatement of Road Surface.		o	o
209 -	Scarification of Existing Road/ Breaking of Road Pavement Structure.		o	o
210 -	Pavement Widening and Grooving of existing surface.		o	o
211 -	Lime Stabilized Aggregate Base Course.	o		
212	Bitumen Stabilized Subbase or Base.	o	o	
213 -	Cold Recycling of Road Pavement Structure/Soil Stabilisation.		o	
214 -	Asphaltic Base / Binder Course		o	
215 -	Geotextiles	o		

SECTION-III

SURFACE COURSES AND PAVEMENT.

Item No	Description	New Construction	Rehabilitation	Maintenance
300 -	General.	o	o	o
301 -	Asphaltic Materials.	o	o	o
302 -	Bituminous Prime Coat.	o	o	o
303	Bituminous Tack Coat.	o	o	o
304 -	Bituminous Surface Treatment and Seal Coat.	o	o	o
305 -	Asphaltic Concrete Wearing Course, Plant Mix.	o	o	
306 -	Shoulder Treatment.	o	o	o
307 -	Bit-Mac.		o	o
308 -	Hot Recycling of Asphalt Concrete		o	
309 -	Cold Milling		o	o
310 -	Concrete Pavements.	o	o	o

SECTION-IV

STRUCTURES

Item No	Description	New Construction	Rehabilitation	Maintenance
400 -	General - Structures.	O	o	o
400A -	Bridges and Culverts.	O	o	
401 -	Concrete.	O	o	o
402 -	Falsework & Centring for Bridges	o	o	o
403 -	Formwork.	o	o	o
404	Steel Reinforcement.	o	o	o
405 -	Prestressed Concrete Structures.	o		
406 -	Joints & Bearing Devices for Concrete	o	o	
407 -	Piling.	o		
408 -	Sheet Piling.	o		
409 -	Well Foundation	o		
410	Brick Masonry	o	o	o
411 -	Random and. Dressed Uncoursed Stone Masonry.	o	o	o
412 -	Dressed Coursed Stone Masonry.	o	o	
413 -	Steel Structures.	o	o	

SECTION-V

DRAINAGE AND EROSION WORKS.

ITEM NO	DESCRIPTION	New Construction	Rehabilitation	Maintenance
500 -	General - Drainage & Erosion Works.	o	o	o
501 -	Reinforced Concrete Pipe Culverts	o	o	o
502 -	Bed to Concrete Pipe Culverts.	o	o	o
503 -	Underdrain.	o	o	
504 -	Headwalls, Wingwalls, Parapets, Approach Slabs, Aprons and siphon inlets / outlets.	o	o	o
505 -	Manholes.	o	o	o
506 -	Drop Inlets and Catch Basins.	o	o	o
507 -	Gabions	o	o	o
508	Brick Paving.	o	o	o
509 -	Riprap and Reinforced Concrete Slope Protection.	o	o	o
510 -	Dismantling of Structures and Obstructions.	o	o	o
511 -	Stone Pitching.	o	o	o
512 -	Ditch Lining and Wash Checks.	o	o	o

SECTION-VI

ANCILLARY WORKS.

Item No	Description	New Construction	Rehabilitation	Maintenance
600 -	General - Ancillary Works.	o	o	o
601 -	Concrete Kerbs, Gutters and Channels.	o	o	o
602 -	Asphalt Concrete and Cement Concrete Side Walk.	o	o	o
603 -	Brick Edging.	o	o	o
604 -	Metal Beam Guard-rail.	o	o	o
605 -	Concrete Beam Guard-rail.	o	o	o
606 -	Bridge Railing.	o	o	o
607 -	Traffic Signs and Safety Devices.	o	o	o
608 -	Pavement Marking.	o	o	o
609 -	Reflectorized Pavement Studs.	o	o	o
610 -	Precast Concrete Posts & Markers.	o	o	o
611 -	Fencing.	o		
612 -	Furnishing and Planting Trees, Shrubs and Ground cover.	o	o	o
613 -	Sprigging and Sodding.	o	o	o

SECTION-VII

MISCELLANEOUS

Item No	Description	New Construction	Rehabilitation	Maintenance
701 -	Provision of Survey Teams and Instruments.	o	o	
702 -	Provide, Equip and Maintain Office Facility to the Engineer. (Base Camp Facility)	o	o	
703 -	Provide, Equip and Maintain Laboratory for the Project.	o	o	o
704 -	Maintenance of Works for One Year after completion (Period of Maintenance.)		o	o
705 -	Temporary Road Works for Traffic Diversion.		o	o
706 -	Control and Protection of Traffic.		o	o

EARTH WORK
AND
ALLIED ACTIVITIES

EARTHWORK

SECTION 100 G E N E R A L

100.1 DESCRIPTION

Earthwork will consist of all necessary work for the excavation and placing in embankment or backfill or disposal by dumping of earth, rock or other material from or to the roadway or adjacent thereto or from borrow areas, including the excavation of side and interception ditches, the removal of unsuitable subgrade material, the formation of laybyes, the widening of cuts and the flattening of cut slopes whether to obtain material for embankments or backfill, or to increase the stability of the slopes, clearing and grubbing, the selective removal of trees, stripping and the removal of existing obstructions within the approved cross section for excavation, in accordance with these specifications and in conformity with the lines, grades, sections, and dimensions shown on the drawings or as directed by the Engineer.

100.2 SOIL INFORMATION

Any information concerning the properties of the soil or sub soil and other geotechnical information shown on the drawing or other documents forming part of the contract is for information only. The contractor is supposed to make his own assessment of site conditions prevailing. No claim for extra cost or time extension will be entertained based on the information provided.

The Contractor shall be deemed to have visited the site prior to making his bid and shall ascertain the nature of the earth and rock, its quantity, locations and suitability to meet the specified requirements, and he shall base his bid estimates solely on his own soil investigation. After the award of the contract no claim for a revision of bid prices depending on the sources of soil information will be entertained.

100.3 EXPLOSIVES

Where explosives are used the Contractor shall provide suitable buildings or warehouses in approved positions for the storage of explosives, which shall be stored in the manner and quantity approved by the Engineer or as per relative laws of government. Such storage places shall be accessible only to authorized personnel. They shall be properly marked; all doors or accesses thereto shall be constructed of materials as directed by the Engineer and provided with secure locks and all necessary means for preventing access by unauthorized persons. The Contractor shall be responsible for the prevention of any unauthorized issue or improper use of any explosives. The handling of explosives shall be entrusted only to experienced and responsible men, to the satisfaction of the Engineer, and in conformity with the statutory regulations.

All drilling and blasting shall be done in such a manner as to bring the excavation as close as possible to the required cross sections, and to disturb as little as possible the material to be left in place. Blasting by means of drill holes, tunnels, or any other method shall be performed at the entire risk and responsibility of the Contractor who shall have no claim to payment for extra work occasioned by breakage outside the approved cross-sections or dimensions.

The greatest care shall be taken by the Contractor during all blasting operations to ensure that no injury be done to persons or damage to property or to the finished work. Shots shall be properly loaded and capped, and only a moderate charge shall be used in each hole. A record of all explosives used, showing locations and amounts, shall be kept by the Contractor for checking by the Engineer.

Where directed by the Engineer, the Contractor shall provide heavy mesh blasting mat for protection of persons, property and the work. If necessary, blasting shall be restricted to time prescribed by the Engineer.

The Engineer may prohibit blasting and order the rock to be excavated by other means, if, in his opinion, it would be dangerous to persons or adjacent structures, or is being carried out in a reckless manner. If traffic on the road has to be interrupted, the Contractor shall obtain approval of his schedule for such interruption from the proper authorities and shall satisfy the Engineer that he has obtained it. No extra payment shall be admissible for such arrangements as described here above.

100.4 REMOVAL OF EXISTING OBSTRUCTIONS

The pay items under Items 101, 103, 105, 106, 107 and 108 shall include the cost of removal of all material regardless of its nature, encountered within the limits of the approved cross-section, including the removal and disposal, as required by the Engineer, of existing brick, stone, concrete or masonry, rock boulders or fragments, old pavements, culverts, bridges or parts thereof, retaining walls or any other material encountered during the excavation, unless a separate item exists for such features.

100.5 REMOVAL OR DIVERSION OF WATER

Except where provided for, no separate payment will be made for control of or removal of water during or after earthwork operations. The cost of sheeting, shoring, cofferdams, pumping and draining shall be included in the bid prices for earthwork. The Contractor shall provide necessary facilities for dewatering and for draining or diverting watercourses when necessary for the protection of the contract work or where required by the Engineer.

The Contractor shall provide such drainage outlet ditches or canals as may be necessary to effect proper drainage before rain is expected. Such drainage ditches or canals for protection of work during construction and their maintenance and clearing to make them continuously effective during the work shall not be paid separately, but shall be deemed to be included in other items of work.

The Contractor shall also provide, fix, maintain and operate such engines, pumps, hoses, chutes and other appliances as are necessary to keep the accumulated water at a level required for the safety of the structures as directed by the Engineer.

100.6 DITCHES

The Contractor shall construct side ditches, interception ditches, and inlet and outlet ditches as shown on the Drawings or where ordered by the Engineer, whether for temporary or permanent drainage. In order to keep water away from the embankment, subgrade, and/or pavement during construction, the Contractor shall at all times ensure adequate drainage by scheduling ditch and outlet so that the drainage is operative before work is started on the embankment, subgrade or pavement. He shall clean and trim all such drainage ditches from time to time, so that there may be a free flow of water throughout the whole period of the Contract. Ditches shall first be trimmed according to approved cross-sections, and final trimming, including the repair of any damage that may have been done during the construction work, shall be carried out after the completion of the other construction work and shall be a condition for final approval and acceptance.

Unless otherwise specified no separate payment will be made for the excavation of side ditches, interception ditches, inlet and outlet ditches but such payment will be made under item 105 or 106 whichever applicable.

Where indicated on the drawings or when required by the Engineer, the Contractor shall take cross-sections of existing stream channels, and in collaboration with the Engineer, mark them with details of the excavation required for the relocation of the stream channel. Work shall not proceed without written approval of the marked cross-sections by the Engineer.

100.7 EXCAVATION FOR CULVERTS

Except where otherwise specified excavation and backfill for culvert and drainage pipes, except granular backfill to under drains, will not be paid for separately, but shall be considered as a subsidiary obligation of the Contractor covered under the contract price for the various classes of pipe culvert as provided in Item 501.

100.8 LANDSLIDES, BENCHES, FLATTENING OF SLOPES

The Engineer may order the removal of material resulting from landslides, the construction of benches in or above the cut slope or in the embankment slope or where in his opinion the slope shows signs of instability, the flattening of the slope. Payment of all such work shall be at contract prices in Item 106 or 108 as the case may be.

100.9 SURVEY AND LEVELING PRIOR TO COMMENCEMENT OF EARTHWORK

The Contractor shall be responsible for the setting out of the work in accordance with Clause 17 of the General Conditions of Contract. Notwithstanding that project drawings have been issued to the Contractor,

the Contractor shall also be responsible for taking joint cross-sections on the proposed alignment of the road, submitting three copies of the plotted cross-sections and longitudinal profile to the Engineer and obtaining the approval of the Engineer to such cross-section and longitudinal profile before any work in connection with Earthwork is commenced. These cross-sections and longitudinal profile shall be in the form and manner as instructed in writing by the Engineer.

100.10 MEASUREMENT AND PAYMENT

The quantities of the various classes of excavation or embankment to be measured for payment under the contract shall be limited to the lines and level as taken under clause 100.9 above. However if the levels so taken differ appreciably from design levels the mater shall be referred to the client.

Excavation and filling beyond the lines and level shown on the drawings, approved profiles and cross-sections will not be paid for. The Engineer will decide the angle of the slope of cuts and fills as the work proceeds on the basis of evaluation of the soil characteristics. The actual lines of the cuts and fills as made will be duly measured and recorded by the Contractor. The Engineer will check these records and will approve the measurements, if correct, as a basis of payment. Excess of excavation shall be backfilled, as directed by the Engineer, with subbase materials without extra payment to the Contractor; excess of fill may be either left in place or removed as required by the Engineer. The quantities of excavation, backfill and earthwork to be paid for in Items 103, 106, 107 and 108 respectively shall be the number of cubic meters of material measured by the average end-area method, except where the error may exceed plus or minus five percent as compared with the prismoidal formula in which case the Engineer will authorize the use of the more accurate method. However, the Contractor shall request such authority before he submits his quantities for approval. Quantities measured on the average end-area basis, once they have been submitted and approved, shall not be subject to review for the purpose of applying a more accurate method.

SECTION 101 CLEARING AND GRUBBING

101.1 DESCRIPTION

This work shall consist of removal to the specified depth, grubbing and disposal of all surface objects, as and where directed in writing by the Engineer, stumps, roots, bushes and trees with less than 150 mm girth, vegetation, logs, rubbish and other objectionable material, except such objects as are designated to remain or are to be removed in accordance with other section of specification.

101.2 CONSTRUCTION REQUIREMENTS

101.2.1 Clearing/Grubbing

In roadway cut areas, all surface objects or any object to the depth of 30 Cm below subgrade level such as stumps, roots, vegetation, bushes, logs, rubbish shall be cleared and/or grubbed as directed by the Engineer, thereby proceeding for excavation. In roadway fill areas where clearing and grubbing is required, same shall be carried out to the depth of 30 Cm below natural surface level as described above.

Operation of clearing and grubbing shall in no way be deemed to effect any level or volume change of the area.

After clearing and grubbing, the compaction of the area will be restored to its original value, without any extra payment. However, Engineer may direct in writing to the Contractor for stripping (if so required) under item 103 or for compaction under item 104, Compaction of Natural Ground, if the original compaction is less than the required for respective zone. Payment of these items will be made separately under the relative items used for such purpose.

Before bottom layer of embankment is placed, contractor will grub up and remove without extra payment, any vegetation that may, in the meantime have grown on surface previously cleared and grubbed.

All trees having girth less than 150 mm measured at (600) mm above ground and falling within the construction limits shall be felled & removed by the contractor under this item. The excavation and removal of trees, roots and stumps including backfilling and compacting of holes and restoring the natural ground to the original condition shall be responsibility of the contractor for which no extra payment shall be made to him. The trees, stumps & roots remain the property of the Employer, which shall be delivered at designated place as directed by the Engineer.

101.2.2 Protection and Restoration

The Contractor shall prevent damage to all pipes, conduits, wires, cables or structure above or below ground. No land monuments, property markers, or official datum points shall be damaged or removed until the Employer/Engineer has witnessed or otherwise referenced their locations
and approved their removal. The Contractor shall so control his operations as to prevent damage to shrubs, which are to be preserved. Protection may include fences and boards latched to shrubs, to prevent damage from machine operations. Any damage as a result of contractor's operation shall immediately be rectified by him at his own expense.

101.3 MEASUREMENT AND PAYMENT

101.3.1 Measurement

Clearing and grubbing will be measured for payment only on areas so designated in writing by the Engineer or shown on the drawings. The quantity to be paid for shall be the number of square meters satisfactorily cleared and grubbed. Any tree having girth of less than 150 mm (measured 600 mm above ground level) shall be measured to be under this item.

Engineer shall ensure that a minimum of 500 SM area is designated for clearing and grubbing in any stretch of roadway for the sake of ease to construction activities.

Clearing and grubbing carried out by the Contractor in roadway cut areas and borrow pits shall not be measured for payment.

101.3.2 Payment

The quantities determined as provided above will be paid for at the contract unit price for the pay item mentioned below and shown in the Bill of Quantities, which price and payment shall be full compensation for clearing and grubbing and restoration of area, to its original condition.

Pay Item No.	Description	Unit of Measurement
101 a	Cleaning & grubbing (removal) of roots including scarifying natural ground up to 12" (30cm) depth and disposal of roots	SM

SECTION 102 REMOVALS OF TREES

102.1 DESCRIPTION

This work shall consist of the removal of trees and stumps along with their roots to a depth, to ensure complete removal of roots and stumps and their disposal as provided in Special Provision or as directed in writing by the Engineer.

102.2 CONSTRUCTION REQUIREMENTS

Such individual trees as the Engineer may designate and mark in white paint shall be left standing uninjured. All other trees to be removed shall be counted and an inventory prepared showing girth of the tree stem at 600 mm from ground.

When necessary to prevent injury to other trees or structures or to minimize danger to traffic, trees shall be cut in sections from top downwards.

Whole or loose earth resulting from the removal of trees shall be filled and re-compacted to a degree of compaction of adjoining area. Any extra material required for such purpose shall Not be measured for payment.

102.3 GENERAL REQUIREMENTS

Contractor shall prevent damage to all under-ground utilities, such as pipes cables or conduits etc. For this purpose if so required, removal of trees shall be carried out manually. Any under-ground or over-ground property damaged by the contractor shall be immediately repaired by the contractor at his own expense.

102.4 MEASUREMENT AND PAYMENT

102.4.1 Measurement

Engineer and Contractor shall jointly measure the girth and number of trees to be removed under this item. Any tree having a girth of less than 150 mm measured six hundred (600) mm above ground level shall Not be measured under this item, as the same shall be removed under item "Clearing and Grubbing".

102.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price for the pay item mentioned below and shown in the Bill of Quantities which price shall be deemed to include all cost of labour equipment and incidental related to the item.

Pay Item No.	Description	Unit of Measurement
102 a	Tree removal along with its roots including backfilling for	
	i. Girth 150mm – 300mm	NO
	ii. Girth 301mm – 600mm	NO
	iii. Girth over 600mm	NO

SECTION 103 STRIPPING

103.1 DESCRIPTION

This work shall consist of removing unsuitable topsoil, transporting and depositing in stockpiles or spreading where indicated on the Drawings or as directed by the Engineer. Engineer shall give instruction in writing, stating area and depth to be stripped.

103.2 CONSTRUCTION REQUIREMENTS

The areas from which stripping of topsoil is required shall be as indicated on the Drawings or as directed by the Engineer. The Contractor shall remove topsoil from these areas to depth as directed by Engineer. Stripping of topsoil in any case shall be not less than 10 cm. in depth. The removed topsoil shall be transported, deposited in stock piles at locations designated by the Engineer and/or spread where indicated on the drawings or as directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests

The top soil shall be placed separately from other excavated materials and be completely removed to the required depth from the area prior to the beginning of regular excavation or embankment work in that area. No payment will be made for topsoil removed from places other than that directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests, before such a decision.

103.3 MEASUREMENT AND PAYMENT

103.3.1 Measurement

Measurement shall be made by multiplying the length, breadth and depth of layer approved by the Engineer in cubic meter of material removed and disposed as directed by the Engineer. However space thus created shall be filled by the material as directed by the Engineer and paid separately under relative item.

103.3.2 Payment

The payment under this item shall be made for at the contract unit price per cubic meter of stripping measured as above, for removal of material to a depth approved by the Engineer including its disposal at designated place and in the manner as directed by the Engineer.

Pay Item No.	Description	Unit of Measurement
103 a	Stripping	CM

SECTION 104 COMPACTION OF NATURAL GROUND

104.1 DESCRIPTION.

The natural ground or surface ready for construction purposes after clearing and grubbing or stripping, (if required) will be considered as (natural) Ground for the purpose of this item. The compaction of natural ground shall be carried out through a written order by the Engineer.

104.2 CONSTRUCTION REQUIREMENTS.

Up to a depth of twenty (20) cm below the natural ground, all sods and vegetable matters shall be removed and clear surface shall be broken up by ploughing and scarifying to compact to the degree as defined below:

For height of Embankment below sub grade level.	Percent of Maximum Dry Density as determined by AASHTO T-180. *
0 to 30 cm	95
30 to 75 cm	93
Over 75 cm	90
Below the foundation of structures	95

104.2.1 Compaction of original ground surface in areas of high water levels and salinity.

Compaction of the natural ground surface in such areas will be difficult if not impossible. See Items 108, etc. under Formation of Embankment for construction requirements under these conditions, where compaction of Natural Ground shall not be carried out.

104.2.2 Hand Packed filling behind walls.

Hand packing shall be carried out in areas where equipment access is not possible. Hand packed filling shall be carried out using medium (Type II & III) or hard rock (Type IV, V &VI) as specified. Hand packing shall be done in such a way so as to form a stable, dense and properly interlocked mass of rock fill, as per instructions of the Engineer.

104.3 MEASUREMENT AND PAYMENT.

104.3.1 Measurement.

The measurement shall be made by multiplying the length and breadth of the area approved in writing by the Engineer to be paid under this item. The measurement of the item shall be in Square meter.

Any subsidence of levels of Natural Ground due to compaction under this item shall not be measured for payment, the contractor is expected to take care of such factors while bidding.

104.3.2 Payment.

The payment under this item shall be made for at the contract unit price for Square meter of compaction of (natural) ground measured as above and shall be deemed to include cost of scarification, watering, mixing, leveling, rolling, labour, equipment, tools, and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
104 a	Compaction of natural ground	SM
104 b	Compaction of boulders, soft rock (Type I) etc.	SM
104 c	Hand Packed filling of medium (Type II & III) & hard rock (Type IV, V &VI).	SM
u		
n		

SECTION 105 ROADWAY AND BORROW EXCAVATION FOR EMBANKMENT

105.1 DESCRIPTION

The work shall consist of excavating the roadway and borrow pits, removal and satisfactory disposal of all materials taken from within the limits of the work, also such excavation as is necessary for inlet and outlet ditches of structures and shall include all excavation, shaping and sloping for the construction, preparation of all embankment, subgrade, shoulders, intersections and approaches as directed and in conformity to the alignment, grade, level and cross-sections shown on the plans or established by the Engineer.

105.2 CLASSIFICATION OF EXCAVATION

105.2.1 Road Way Excavation

Roadway Excavation shall comprise all excavation that is not classified as structural excavation carried out within the limits of roadway including permanent drainage ditches and side slopes in cut.

Roadway Excavation shall further, be classified as "Common Excavation", or "Rock Excavation", (common excavation shall include all the materials of whatever nature encountered but not including rock excavation).

a) Common Excavation

Common excavation shall consist of the removal and satisfactory disposal of all eolian, alluvial and residual materials, in place unaltered and un weathered strata, which are not firm or rigid enough to possess all the characteristics of "Rock Excavation". Boulders of less than one quarter (1/4) cubic meter volume shall also be classified as "Common Excavation". Eolian and alluvial materials consist of gravel, shale, volcanic ash, loess, dunes and, loams, sands and clays or any combination of these materials, and termed as Common Excavation.

b) Rock Excavation

This includes firm and rigid igneous, metamorphic and sedimentary rocks. Boulders larger than quarter (1/4) cubic meter in volume will also be considered as "Rock Excavation", provided these are firm and stable lying in continuous bed and constitute more than 50% by volume as compared to other type of materials in the total mass.

The classification of Hard, Medium or Soft Rock shall be same as described under item 106.2 of General Specifications.

105.2.2 Borrow Excavation

Borrow Excavation shall comprise all excavation taken from borrow pits. Material from borrow pits shall normally be used for the construction of embankment or for the backfill when there is no material available from roadway excavation or structural excavation. Permission to use material from borrow pit shall first be obtained in writing from the Engineer. Never the less the total quantity of material from roadway excavation and structural excavation after deduction of the material declared unsuitable by the Engineer, shall be considered available for use in the work and any material used from borrow pits for formation of embankment shall not be measured for payment.

In making his bid, the Contractor shall inspect the site and prepare his estimate of the haulage cost on the basis of his own survey of the possible nature and locations of the borrow pits. Their distance from the work sites shall not be grounds for extra payment or revision of the contract price.

The consent of the landowner or tenant for excavating the borrow material and hauling along private access roads shall be secured by the Contractor who shall, if required, pay for such concession. Borrow pits shall be left in a condition acceptable to the landowner and/or tenant and the Engineer.

105.2.3 Structural Excavation

The description method of measurement and payment of this section shall conform to as specified in item 107.

105.3 CONSTRUCTION REQUIREMENTS

All material removed from excavation shall be used in the formation of embankment, sub grade, shoulders, and at such other places as directed, unless it is declared unsuitable and ordered to waste by the Engineer. No excavated material shall be wasted without written permission from the Engineer, and when such material is to be wasted, it shall be so placed that it will present a neat appearance and not offer any danger to abutting property.

The material shall be declared unsuitable if the soaked CBR (96 hours) is less than five (5) percent or if falls under A-6 or A-7 of AASHTO soil classification.

During construction of the roadway, the road bed shall be maintained in such a condition that it will be well drained at all times.

All slopes, except in solid rock or other material shall be trimmed precisely as per cross-sections, and care must be exercised that no material shall be loosened beyond the required slopes. In blasting rock slopes, a reasonably uniform face shall be left, regardless of whether or not the excavation is carried beyond the specified side slope. All breakage and slides shall be removed by the contractor and disposed of as directed by the Engineer.

Rock, shale and other unsuitable road bed material encountered in cuts shall be excavated to required width and depth indicated on the plans or as otherwise directed. Any over breakage below the depth shown on the plans will not be paid for. Backfill of the overcut shall be of approved earth material and shall have the same density requirements as specified on the plans and shall be at the expense of contractor.

Borrow pits shall be located so that the nearest edge of the pit is at least thirty (30) meters from the roadway toe of slope unless otherwise directed by the Engineer.

Permission to use any borrow material, including its suitability, shall be obtained in writing from the Engineer before execution of work. It is responsibility of the contractor to submit a request for test at least fifteen (15) working days prior to the day the contractor intends to begin taking material from the borrow area.

In no case shall borrow material be obtained from downstream of any hydraulic structure. However, the borrow pit may be established at five hundred (500) meters upstream of the hydraulic structure. The side slopes of the pits or channels shall be constructed as shown on the plans or as directed by the Engineer. In no case the side slopes of borrow pit is steeper than a slope; 1:5 (V: H).

Upon abandonment of borrow pit or quarry area, the contractor shall, at his own expense, clean and trim the borrow pit or quarry area, the right of way, and adjoining properties which were occupied during execution of work, all to the satisfaction of the Engineer.

All drilling and blasting shall be done in such a manner as will most nearly complete the excavation to the required grade line, and produce the least disturbance of the material to be left in place. Blasting by means of drill holes or any other methods shall be

performed at the entire risk and responsibility of the contractor. Care shall be taken to ensure that no injury be done to persons or properties or to the finished work. Blasting shall be restricted to the hours prescribed by the local authorities or the Engineer.

Where between two successive cross-sections of the road, the properties of rock boulders, in sizes larger than a one quarter (1/4) of a cubic meter and its ratio to earth is more than 50%, the excavation will be considered wholly as rock.

Rock material above ground level such as stones, boulders, piles of stone, and dry stones walling whose individual sizes are greater than one quarter of a cubic meter shall be removed and disposed of if directed in writing by the Engineer and shall be paid under relevant item of work in the Bill of Quantities.

105.4 MEASUREMENT AND PAYMENT

105.4.1 Measurement

When the Bill of Quantities specifies for "Common Excavation", "Rock Excavation" and "Borrow Excavation" the quantities of the different classes of excavation shall be computed as follows:

a) Common Excavation

The unit of measurement for common excavation shall be in cubic meter and be computed by average end area method based on cross-sections duly approved by the Engineer prior to commencement and completion of required excavation.

The excavated material approved for fill under any item of the Bill of Quantities shall be used in the manner as described under the relevant item of work, irrespective of haulage distance.

b) Rock Excavation

Authorized "Rock Excavation" to be measured in cubic meters shall consist of area that is necessary to provide the design section and grade or as directed by the Engineer. Any over breakage beyond the lines shown on the plans and outside of the tolerances set for sub grade in cuts shall not be paid for. The Engineer shall define the beginning and ending points of areas classified as "Rock Excavation". Any area over excavated in the sub grade shall be reinstated at the cost of contractor as directed by the Engineer.

The pay quantity for "Rock Excavation" shall be computed by means of average end area method from approved cross-sections based on original ground elevations after the authorized removal of unsuitable or overburden materials, if required.

For disposal of excavated rock material, same procedure shall be followed as described above for the "Common Excavation" specified in sub item No.105.4.1 (a).

c) Borrow Excavation

No measurement shall be made for any Borrow Excavation; however, this material if used in any of the Bill items shall be measured and paid as provided under the relative items of work.

105.4.2 Payment

No payment for Roadway or Borrow Excavation shall be made under this item as the same is deemed to be included under relative item of Formation of Embankment.

SECTION 106 EXCAVATION OF UNSUITABLE OR SURPLUS MATERIAL

106.1 DESCRIPTION

The work shall consist of excavation and disposal of unsuitable or surplus material arising from roadway excavation, which is declared in writing by the Engineer to be unsuitable for use or surplus to the requirements of the project. When excavation of unsuitable material requires special attention for a known condition on a specific project then construction requirements and payment shall be covered under relevant Provisions.

106.2 DEFINITIONS

a) Surplus Earthwork, is that portion of excavation, which is more than that quantity, which is used in Backfill of road.

b) Borrow Earthwork, is that quantity of fill, which is not available from excavation in roadway and comes from outside approved sources.

c) Unsuitable Earthwork, is the quantity earthwork, coming from roadway excavation, but cannot be used in Backfill, due non-conformance of the material with specifications, required for backfill.

Working of various quantities of Earthworks.

a) Total Earth Cut = (X)

b) Total Earth Fill = (Y)

c) Surplus Earthwork = (X-Y) (for Cut > Fill)

d) Borrow Earthwork = (Y-X) (for Fill > Cut)

In case of portion of cut being unsuitable material (Z), following will be the situation:

a) Suitable Cut material = (X-Z)

b) Surplus Earthwork = [(X-Z)-Y]

c) Borrow Earthwork = [Y-(X-Z)]

Rock excavation shall be classified as under:

Classification of Rocks based upon Geology for Earthwork

Category	Rock type	Material/Rock Type and Name	U.C.S (Unconfined compressive Strength) MPa	Dry Density t/m^3	Field Propertied of Rocks	Work Type
Soft	I	Coal(Soft)	5-25	1.4	Crumble under blows break with hammer and hand	Pick Work/Jumper work
		Gypsum	20-25	2.2	Dent by finger nail white in color	Jumper work
		Salt	5-20	2.1	Show cubical cleavage ductile deformation in stress	Jumper work
		Clay	1-4	1.8	Mold by finger,	Pick Work

					break by hammer if compacted	
		Mudstone(soft)	10-25	2.3		
		Shale (soft)	05-25	2.3		
		Chalk (soft)	05-25	1.8		
		Slate (Soft)	20-25	2.7		
Medium	II	Gypsum (medium)	25-100	2.2	Break by hammer crumble under pick blows. Break by hand.	
		Mudstone	25-50	2.3		Pick Work/Jumper work
	III	Weathered Sandstone	25-40	1.9	Moderately strong rock , break by hammer	Jumper work/blasting work
		Dolomite (medium)	50-100	2.5		
		Gneiss (medium)	50-100	2.7		
		Schist (medium)	20-100	2.7		
		Marble (medium)	60-100			
		Conglomerate	variable	variable	Moderately medium	Brake by hammer
		Slate (Medium)	25-100	2.7		
		Weathered limestone (medium)	50-100	2.6		
		Granite (medium)	50-100	2.7		
Hard	IV	Dolomite	100-150	2.5	Moderately strong rock, break by hammer	
		Gneiss	100-200	2.7	Strong break by hammer	
		Marble	100-200	2.6	Moderately strong rock, break by hammer	
	V	Sandstone (Greywacke)	100-200	2.6	Blasting generally required	Jumper work/chiseling
		Conglomerate	variable	variable	Ripping & blasting required if cemented conglomerate and limestone hard bed.	Jumper work/chiseling
		limestone	100-150	2.6		Jumper work/chiseling
	VI	Granite	100-350	2.7	Blasting, chiseling and ripping required to break, very strong rocks. Mostly rocks are igneous and metamorphic.	Jumper work/chiseling
		Basalt	100-350	2.9		
		Quartzite	100-350	2.9		Blasting work
		Dolerite	100-350	2.9	Blasting, chiseling and ripping required	Blasting work

					to break, very strong rocks. Mostly rocks are igneous and metamorphic.	

Note: The above rock classification is based on the following strength criteria. Any rock from the above table, or not shown in the table will be classified accordingly.

Soft Rock: < 25 MPa

Medium Rock: 25 – 100 MPa

Hard Rock: > 100 MPa

a) Hard Rock

Any rock which cannot be removed with Ripper of a 200 H.P. Bulldozer and constitutes a firm and continuous bed of rock only.
(Compressive Strength > 100 MPa)

b) Medium Rock

Any rock which cannot be removed with the blade of 200 H.P. Buldozer but can be removed by the ripper, will be termed as Medium Rock, irrespective of the fact that it is removed by blasting. (Compressive Strength 25 MPa – 100 MPa)

c) Soft Rock

Any rock which can be removed with the blade of a 200 H.P. Bulldozer. This item will be termed as Soft Rock, irrespective of the fact that it is removed by blasting. (Compressive Strength < 25 MPa)

106.3 CONSTRUCTION REQUIREMENTS

All suitable material excavated within the limits and scope of the project shall be used in the most effective manner for the formation of the embankment, for widening of roadway, for backfill, or for other work included in the contract.

Any material surplus to these requirements or any material declared in writing by the Engineer to be unsuitable shall be disposed of and leveled in thin layers by the Contractor outside the right of way as directed by the Engineer. The Engineer shall decide regarding the unsuitability of the material by conducting appropriate laboratory tests.

When unsuitable materials are ordered to be removed and replaced, the soil left in place shall be compacted to a depth of twenty (20) cm to the density prescribed under Item 108.3.1. Payment for such compaction shall be included in the contract prices for the excavation materials.

If the unsuitable material, which is to be removed, is below standing water level and the replacement material is gravel or a similar self-draining material of at least thirty (30) cm in depth, the compaction may be dispensed with if approved by the Engineer.

106.4 MEASUREMENT AND PAYMENT

106.4.1 Measurement

When the contractor is directed to excavate unsuitable material below the surface of original ground in fill areas, the depth to which these unsuitable materials are to be removed will be determined by the Engineer. The contractor shall schedule his work in

such a way that authorized cross sections can be taken before and after the material has been removed. Only material which is surplus to the requirements of the project or is declared in writing by the Engineer to be unsuitable will qualify for payments under pay Item No. 106 a, 106 b, 106 c, and 106 d as the case may be.

The cost of excavation of material which is used anywhere in the project shall be deemed to be included in the pay Item relating to the part of the work where the material is used.

The under mentioned Pay Item Nos. 106 a, 106 b, 106 c, and 106 d shall include the cost of obtaining the consent of the owner or tenant of the land where the disposal of surplus or unsuitable material is made.

Unsuitable or surplus material shall be measured in its original position and its volume shall be calculated in cubic meters using end area method.

106.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay Items listed below and shown in the Bill of Quantities which prices and payment shall constitute full compensation for all costs involved in the proper completion of the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
106 a	Excavate unsuitable common material including disposal up to 30m.	CM
106 b	Excavate unsuitable rock material including disposal up to 30m.	
	i. Hard rock (Compressive strength more than 100 MPa) with blasting allowed	CM
	ii. Hard rock (Compressive strength more than 100 MPa) with blasting prohibited	CM
	iii. Medium rock (Compressive strength 25MPa to 100 MPa)	CM
	iv. Soft rock (Type I, compressive strength up to 25 MPa)	CM
106 c	Excavate surplus common material including disposal up to 30m.	CM
106 d	Excavate surplus rock material including disposal up to 30m.	
	i. Hard rock (Compressive strength more than 100 MPa) with blasting allowed	CM
	ii. Hard rock (Compressive strength more than 100 MPa) with blasting prohibited	CM
	iii. Medium rock (Compressive strength 25MPa to 100 MPa)	CM
	iv. Soft rock (Type I, compressive strength up to 25 MPa)	CM
106 e	Loading, carriage and disposal of all types of excavated unsuitable or surplus material (common soil, sand, boulders, rock etc.) at disposal site.	
	i. Up to 1 km	KM
	ii. For every additional 1 km	KM

SECTION 107 STRUCTURAL EXCAVATIONS AND BACKFILL

107.1 DESCRIPTION

Structural excavation shall include the removal of all material of whatever nature, necessary for the construction of foundations of bridges, culverts, retaining walls, headwalls, wing walls, catch basins, manholes, inlets and other structures not otherwise provided for in these specifications and in accordance with the plans or as directed by the Engineer. It shall include the furnishing of all necessary equipment and construction of all cribs, cofferdams, caissons, dewatering, sheeting, shoring etc., which may be necessary for the execution of the work. It shall also include the subsequent removal of cofferdams and cribs and the placement of all necessary backfill as hereinafter specified. It shall also include the disposing of excavated material, which is not required for backfill, in a manner and in locations so as not to affect the carrying capacity of any channel and not to be unsightly.

107.2 MATERIAL REQUIREMENT FOR BACKFILL

107.2.1 Backfill around structure

Backfill around structure shall be made with the following material.

a. Granular backfill of selected material as specified here under.
b. Common backfill shall be carried out from excavated material or any other borrows material approved by the Engineer.

107.2.2 Granular backfill

Granular backfill material shall meet the following requirements.

a) Grading Requirement

Sieve Size		Percent Passing	
mm	Inch.	A	B
25	1"	100	100
19	3/4"	60-100	75-100
4.75	No. 4	50-85	55-100
2.0	No. 10	40-70	40-100
0.425	No. 40	25-45	20-50
0.075	No. 200	0-15	5-15

b) Material satisfying the requirements of coarse sand falling under soil classification A-3 (AASHTO). In case, coarse sand is utilised for granular fill it shall be ensured that the same is confined properly with approved material.

c) The material shall have a Plasticity Index of not more than six (6) as determined by AASHTO T-89 and T-90.

107.2.3 Common backfill

Use of excavated material as backfill may be allowed under this item. Use of borrow material for common backfill shall be allowed subject to approval of borrow material by the Engineer.

107.2.4 Rock backfill

Rock material of small size shall be permitted in the backfilling of structures or walls subject to the approval of methodology by the Engineer.

107.3 CONSTRUCTION REQUIREMENTS

107.3.1 Structural excavation

a) General

All substructures, where practicable, shall be constructed in open excavation and, where necessary, the excavation shall be shored, braced, or protected by cofferdams in accordance with approved methods. When footings can be placed in the dry without the use of cribs or cofferdams, back forms may be omitted with the approval of the Engineer, and the entire excavation filled with lean concrete to the required elevation of the top of the footing. The additional concrete shall be at the expense of the Contractor.

In case the contractor has excavated additional volumes than specified thereunder, the contractor shall at his own expense backfill the volume with approved material as directed by Engineer.

The classification of Hard, Medium or Soft Rock shall be same as described under item 106.2 of General Specifications.

b) Preservation of channel

Unless otherwise specified, no excavation shall be made outside of caissons, cribs, cofferdams, piling, or sheeting, and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs or cofferdams are in place, the Contractor shall, without extra charge, after the foundation base is in place, backfill all such excavation to the original ground surface or river bed with material approved by the Engineer. Material deposited within the stream area from foundation or other excavation or from filling of cofferdams shall be removed and the stream bed freed from obstruction thereby.

c) Depth of Footings

The elevation of the bottoms of footings, as shown on the drawings, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevation of footings as may be necessary to secure a satisfactory foundation.

d) Preparation of Foundations of Footings

i) All rock or other hard foundation material shall be freed from all loose material, cleaned and cut to a firm surface, leveled, stepped, or roughened, as may be directed by the Engineer.

ii) When masonry is to rest on an excavated surface other than rock special, care shall be taken not to disturb the bottom of the excavation, and the final leveling of the grade shall not be made until just before the masonry is to be placed.

e) Cofferdams and Cribs

i) For substructure work, the contractor shall submit, upon request, drawings showing his proposed method of cofferdams construction and other details left open to his choice or not fully shown on the Engineer's drawings. The Contractor shall not start work until the Engineer has approved such drawings.

ii) Cofferdams and cribs for foundation construction shall be carried to adequate depths and heights, be safely designed and constructed, and be made as water tight as is necessary for the proper performance of the work which must be done inside them. In general, the interior dimensions of cofferdams and cribs shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside the forms. Cofferdams or cribs, which are tilted or moved laterally during the process of sinking, shall be righted, reset, or enlarged so as to provide the necessary clearance and this shall be solely at the expense of the Contractor.

iii) When conditions are encountered which, in the opinion of the Engineer, render it impracticable to dewater the foundation before placing masonry, he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The foundation water shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed and the weight is utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. During the placing of a foundation seal, the elevation of the water inside the cofferdam shall be controlled to prevent any flow through the seal, and if the cofferdam is to remain in place, it shall be vented or ported at low water level.

iv) Cofferdams or cribs shall be constructed so as to protect green concrete against damage from a sudden rising of the stream or river and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry without written permission from the Engineer.

v) Unless otherwise provided, cofferdams of cribs with all sheeting and bracing shall be removed after the completion of the substructure, care being taken not to disturb or otherwise injure the finished masonry.

f) Pumping

i) Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping of water will be permitted during the placing of concrete or for a period of at least twenty four (24) hours thereafter, unless it is done from a suitable sump pit separated from the concrete work by a watertight wall or other effective means.

ii) Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to with stand the hydrostatic pressure.

g) Inspection

After each excavation is completed the Contractor shall notify the Engineer, and no concrete or masonry shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

In case if an existing structure is to be replaced with a new structure the quantities for dismantling the structure shall be paid under item 510 (Dismantling of structures) and additional excavation required shall be carried out under this item.

h) Classification of Excavation

Classification of excavation shall be made as described under items 106.2 of this Specification.

107.3.2 Excavation in Embankments

Unless otherwise specified, the Contractor may choose with the approval of the Engineer to excavate for structures, culverts, and pipe culverts after the embankment has been placed. Any space remaining after the placing of such structures or culverts shall be filled with material approved by the Engineer and compacted as follows:

Layers of not more than 20 cm in loose thickness shall be placed and compacted in succession, with mechanical tampers, plate compactors or hand guided rollers operated transversely to the roadway, to the densities specified in the item 108.3.1. Moisture content shall be adjusted as directed by the Engineer. Proper benching shall be made to ensure bonding of existing and new material without any extra payment.

The excavation in embankment and the placing of backfill for the purposes described above shall not constitute any claim for payment. Also if sand or granular backfill is used by the contractor for his convenience, no extra payment will be made.

107.3.3 Backfill

a) Granular backfill where-ever directed shall be placed in the position and to the required depth, shown on the drawings or where and as required in writing by the Engineer and it shall be well compacted in layers not exceeding twenty (20) cm in thickness to 100 percent of Max. dry density as per AASHTO T-180 (D). In case of water logged areas the thickness of the layer shall not exceed fifty (50) centimeters or as directed by the Engineer. Volume of granular fill around structures shall be calculated within the vertical limits of approved excavation for such a structure, where as the horizontal limits shall be those as specified on drawings.

b) Common backfill shall consist of earth free from large lumps, wood and other organic materials and of a quality acceptable to the Engineer. It shall be placed in the position and to the required depths shown on the Drawings and/or as required in writing by the Engineer and it shall be well compacted in layers not to exceed twenty (20) cms in depth to the density, 95 percent of maximum dry density, as per AASHTO T-180 (D).

c) The rock backfill material whose individual sizes are not more than 30 cm shall be placed in the position to the required depth as specified and the voids shall be filled in layer of fine material approved by the Engineer. The compacting efforts shall be made so as to achieve the desired compaction approved visually by the Engineer. The depth of the layer in any case shall not exceed sixty (60) centimeters. However in water logged areas, the thickness may be increased as directed by the Engineer. Rock backfill will not be placed within two (2) meters from concrete face of any structure.

d) Backfill with Pure Sand (A-3 material) shall be carried out in layers as shown on drawings or as required by the Engineer in writing. It shall be well compacted in layers not exceeding thirty (30) cm in thickness to 100 percent of Max. Dry Density as per ASTM D-4254. Pure sand shall be properly confined prior to compaction.

e) All spaces excavated and not occupied by abutments, piers or other permanent work shall be refilled with earth or granular fill as approved by the Engineer up to the surface of the surrounding ground, with a sufficient allowance for settlement. All such backfill shall be thoroughly compacted and, in general, its top surface shall be neatly graded.

f) The fill behind abutments and wing walls of all bridge structures shall be deposited in well-compacted, horizontal layers not to exceed twenty (20) cm. in thickness. The common backfill in front of such units shall be placed first to prevent the possibility of forward movement.

Special precautions shall be taken to prevent any wedging action against the masonry, and the slope bounding the excavation for abutments and wing walls shall be destroyed by stepping or roughening to prevent wedge action. Jetting of the fill behind abutments and wing walls will not be permitted.

g) Fill placed around culverts and piers shall be deposited on both sides to approximately the same elevation at the same time. Where the Contractor does not have proper equipments to ensure compaction in restricted areas, Engineer may allow backfill with sand saturation method, at no extra cost to the Client.

h) Adequate provision shall be made for the through drainage of all backfill. French drains shall be placed as weep holes.

j) No backfill shall be placed against concrete or masonry structure before fourteen (14) days of placement and backfilling shall be carried out on both sides of the structure simultaneously.

107.4 MEASUREMENT AND PAYMENT

107.4.1 Measurement

a) Structural Excavation

The quantities of structural excavation to be paid for shall be the number of cubic meters of material measured in its original position computed by the average end-area method, and excavated to the satisfaction of the Engineer.

Structural Excavation will be classified for measurement and payment as "Structural Excavation in Common Material", "Structural Excavation in Common Material Below Water Level", "Structural Excavation in Rock Material" and according to whether the excavation is in earth or rock and according to whether the excavation is above or below the water level which is the constant level to which the water naturally rises in a foundation pit.

The volume of earth or rock to be measured for structural excavation shall consist of a prismoid bounded by the following planes:

1) The vertical limits for computing pay quantities will be vertical planes 50 centimeters outside of the neat lines of footings or foundations as shown on the Drawings or as directed by the Engineer.

2) The upper limit for payment of structural excavation shall be the ground surface as it existed prior to the start of construction operations, except where structural excavation is performed within roadway excavation or ditch excavation areas, the upper limit shall be the planes of the bottom and side slopes of said excavated areas.

3) The lower limits for computing pay quantities of structural excavation or structure backfill shall be a plane at the bottom of the completed footings, foundations, structures or lean concrete.

Measurement for structural excavation shall not include material removed below the footing grade and beyond specific limits to compensate for anticipated swell or as a result of effective swell during pile driving, or additional material resulting from slides,

slips, cave-ins, silting or fillings, whether due to the action of the elements or to carelessness of the Contractor. The depths of the footings shown on the drawings are approximate only and any variation found to be necessary during construction shall be paid for at the contract unit price.

b) Granular Backfill

The quantities of Granular Backfill to be paid for shall be the number of cubic meters of material laid and compacted in place within the line of structure and limits defined in Item 107.4.1 (a) above, computed and accepted by the Engineer.

c) Common Backfill

The quantities of Common Backfill to be paid for shall be the number of cubic meters of material laid and compacted, placed within the lines of structure and limits defined in Item 107.4.1(a) above and accepted by the Engineer.

107.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay item listed below that is shown in the Bill of Quantities, which price and payment shall be full compensation for all the costs involved in the proper completion of the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
107 a	Restricted/Structural excavation in common material for any depth as per drawings for any purpose (Foundation, Pipe trenches or Channels etc.) including disposal up to 30m.	CM
107 b	Restricted/Structural excavation in common material below water level for any depth as per drawings for any purpose (Foundation, Pipe trenches or Channels etc.) including disposal up to 30m.	CM
107 c	Structural excavation for any depth as per drawings for any purpose (Foundation, Pipe trenches or Channels etc.) including disposal up to 30m.	
	i. Hard rock (Compressive strength more than 100 MPa) with blasting allowed	CM
	ii. Hard rock (Compressive strength more than 100 MPa) with blasting prohibited	CM
	iii. Medium rock (Compressive strength 25MPa to 100 MPa)	CM
	iv. Soft rock (Compressive strength up to 25 MPa)	CM
107 d	Granular backfill of approved material conforming to Specification of sub base or as specified.	CM
107 e	Common backfill from excavated material within the project area.	CM

SECTION 108 FORMATION OF EMBANKMENT

108.1 DESCRIPTION

This work shall consist of formation of embankment, including preparation of area for placing and compaction of embankment material in layers and in holes, pits and other depressions within the roadway area in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross-section shown on the plans or established by the Engineer.

108.2 MATERIAL REQUIREMENTS

Material for embankment shall consist of suitable material excavated from borrows roadway excavation or structural excavation and shall include all lead and lift. Borrow material will be used only when material obtained from roadway or structural excavation is not suitable or is deficient for embankment formation and shall include all lead and lift.

The material under this item shall conform to the following specification.

a) Contractor shall use AASHTO Class A-1, A-2, A-3, A-4 or A-5 soil as specified in AASHTO M-145 or other material approved by the Engineer.

b) CBR of the material shall not be less than five (5) percent, determined in accordance with AASHTO T-193. CBR value shall be obtained at a density corresponding to the degree of compaction required for the corresponding layer.

c) Swell value of the material for embankment formation shall not exceed five tenth (0.5) percent. However, while establishing the swell value, surcharge weights representing the overburden will be used. In case sandy material is used for embankment formation, it shall be properly confined at no extra payment with a material and to the extent as approved by the Engineer and sandy material shall not be used on slopes of embankment.

d) In areas subject to flood and prolonged inundation of the embankment, such as at bridge sites, the material used in embankment, unless rock, shall be AASHTO Class A1 (a), A1 (b) and A-2-4, soils. Other soils may be used only with the written consent of Engineer.

108.3 CONSTRUCTION REQUIREMENTS

108.3.1 Formation of Embankment with Borrow Common Material

Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings or as required by the Engineer. The layers of loose material other than rock shall be not more than 20 cm. thick, unless otherwise allowed by the Engineer after a trial section is prepared and approved.

The material placed in layers and that scarified to the designated depth for formation of embankment shall be compacted to the density specified below:

Depth in centimeters below subgrade Level	Percent of Maximum Dry Density. as determined by AASHTO T-180. *
0 to 30	95
30 to 75	93
Over 75	90

*Method 'B' or 'D' whichever is applicable or corresponding Relative Density in case of sand fill.

In-place density determinations of the compacted layers shall be made in accordance with AASHTO T-191 or other approved methods. For all soils, with the exception of rock fill materials, containing more than 10% oversize particles (retained on 3/4 inch/ 19 mm sieve), the in-place density thus obtained shall be adjusted to account for such oversize particles or as directed by the Engineer. Subsequent layers shall not be placed and compacted unless the previous layer has been properly compacted and accepted by the Engineer.

Material for embankment at locations inaccessible to normal compacting equipment shall be placed in horizontal layers of loose material not more than 15 centimeters thick and compacted to the densities specified above by the use of mechanical tempers, or other appropriate equipment.

The compaction of the embankment shall be carried out at the designated moisture content consistent with the available compacting equipment.

Embankment material that does not contain sufficient moisture to obtain the required compaction shall be given additional moisture by means of approved sprinklers and mixing. Material containing more than the optimum moisture may not, without written approval of the Engineer, be incorporated in the embankment until it has been sufficiently dried out. The drying of wet material may be expedited by scarification, disking or other approved methods.

When materials of widely divergent characteristics, such as clay and chalk or sand, drawn from different sources, are to be used in the embankment they shall be deposited in alternate layers of the same material over the full width of the embankment to depths approved by the Engineer. Rock, clay or other material shall be broken up, and no accumulation of lumps or boulders in the embankment will be permitted. No surplus material shall be permitted to be left at the toe of embankment or at the top of cut sections.

Side slopes shall be neatly trimmed to the lines and slopes shown on the drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition.

108.3.2 Formation of Embankment With Rock Material

Embankment formed of material consisting predominantly of rock fragment of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding in thickness than the approximate average size of the rocks except that no layer shall exceed eighty (80) centimeters of loose measurement and compacted by a vibratory roller with the minimum mass as shown in the following table 108-1.

Table 108-1: Compaction of Rock Embankment

Mass per meter width of vibrating roll (Kg/M)	Depth of fill layer (mm)	Number of passes of the roller on each layer
2300 – 2900	400	5
2900 – 3600	500	5
3600 – 4300	600	5
4300 – 5000	700	5
>5000	800	5

The material shall be carefully placed in layers, so that all larger stones will be well distributed and voids completely filled with smaller stones, clean small spells, shale, earth, sand, gravel, to form a solid mass. After placing rock material, surface shall be covered with a layer of fine material having thickness less than twenty (20) centimeters. Such fine material shall be reserved from roadway excavation by the Contractor.

Should such material be available but not reserved, Contractor will supply and place borrow material for forming smooth grade without extra payment.

Each layer shall be bladed or leveled with motor grader, bulldozer or similar equipment capable of shifting and forming the layer into a neat and orderly condition. No rock larger than eight (8) centimeters in any dimension shall be placed in the top fifteen (15) centimeters of embankment unless otherwise allowed by the Engineer.

Material for each layer should be consolidated with heavy weight vibratory roller until settlement as checked between two consecutive passes of roller is less that one (1) percent of the layer thickness. In evaluation of settlement, survey points should be established and rolling continued until difference of levels as checked after two consecutive passes is less than one (1) percent of the total layer thickness. More over initial rolling of overlaid fine material shall be done without watering to ensure their intrusion in voids of rock layer beneath. Watering shall be done when voids are properly filled.

Embankments, which are formed of material that contain rock but also contain sufficient compactable material other than rock or other hard material to make rolling feasible, shall be placed and compacted in the manner prescribed above and to the point when settlement is within above mentioned requirement. Compaction test will be made whenever the Engineer determines they are feasible and necessary. Each layer must be approved by the Engineer before the next layer is placed.

When rock to be incorporated in fill is composed largely of weak or friable material, the rock shall be reduced to a maximum size not exceeding fifty (50) percent of the thickness of the layer being placed.

108.3.3 Formation of Embankment on Steep Slopes

Where embankments are to be constructed on steep slope, hill sides or where new fill is to be placed and compacted against existing pavement or where embankment is to be built along one half the width at a time, the original slope of the hill side, of existing pavement or adjacent to half width of embankment shall be cut in steps of twenty (20) centimeters depth. Benching shall be of sufficient width to permit operation of equipment possible during placing and compaction of material.

Cut material shall be incorporated with the new embankment material and compacted in horizontal layers. No extra payment will be allowed for such an operation.

108.3.4 Formation of Embankment on Existing Roads

Before fill is placed and compacted on an existing roadway, the existing embankment and/or pavement may be leveled by cutting, rooting or scarifying by approved mechanical means to a level to be determined by the Engineer. The earth, old asphalt or other material arising as a result of this operation will be declared either suitable or unsuitable, for use in the embankment or other items, by the Engineer. If the material is declared suitable it will be measured under relative item and if it is declared unsuitable, it will be measured under item 106a.

108.3.5 Formation of Embankment in Water Logged Areas

Where embankments are to be placed in water logged areas and which are inaccessible to heavy construction equipment, a special working platform shall be first established, consisting of a blanket of fill material placed on top of the soft layer. The material of the working table shall consist of normal or processed granular fill, obtained from borrow excavation. This material shall conform to the following specifications:

Sieve Description	Percentage of Weight Passing Mesh Sieve, AASHTO T-27
3 inch (75 mm)	100

The remaining grading shall be such as to avoid intrusion into the working platform material of subgrade or natural ground surface material. For this condition to be met it will be required that the ratio.

$$\frac{D_{15}\text{(Working Platform Material)}}{D_{85}\text{ (Natural Ground Material)}} \text{ is less than 5.}$$

D_{85} and D_{15} mean the particle diameters corresponding to 85% and 15%, respectively, passing (by weight) in a grain size analysis.

Construction of this working table shall proceed from one edge of the soft area by using the fill as a ramp for further material transport.

The thickness of the working table as prescribed above shall be approximately 0.5 meter unless directed otherwise by the Engineer, and the width shall be that of the embankment. The placement and compaction of the working table shall be carried out by use of light equipment, as directed by the Engineer.
No density requirements are specified for the working platform, however, subsequent layers above it shall be compacted to the densities specified in Item 108.3.1.

108.3.6 General Requirements

To avoid interference with the construction of bridge abutments and wing walls, the Contractor shall at points determined by the Engineer, suspend work on embankments and/or in cuts forming the approaches to any such structure until such time as the construction of the later is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works. The cost of such suspension of work shall be included in the contract unit prices for embankment. In carrying embankments up to or over bridges, culverts or pipe drainage, care shall be taken by the Contractor to have the embankments brought to equally on both sides and over the top of any such structure. Contractor shall make special arrangements to ensure proper compaction in restricted spaces and around structures. No compensation shall be made to the Contractor for working in narrow or otherwise restricted areas.

When as a result of settlement, an embankment requires the addition of material up to 30 cm in thickness to bring it up to the required grade level, the top of the embankment shall be thoroughly scarified before the additional material is being placed, without extra payment to Contractor for the scarification.

The Contractor shall be responsible for the stability of all embankments and shall replace any portions that in the opinion of the Engineer have been damaged or displaced due to carelessness or neglect on the part of the Contractor. Embankment material which may be lost or displaced as a result of natural causes such as storms, cloud-burst or as a result of unavoidable movement or settlement of the ground or foundation upon which the embankment is constructed shall be replaced by the Contractor with acceptable material from excavation or borrow. No additional compensation will be allowed for the replacement.

During construction, the roadway shall be kept in shape and drained out at all times. When unsuitable material has been placed in the embankment by the Contractor, he shall remove it without extra payment.

108.4 MEASUREMENT AND PAYMENT

108.4.1 Measurement

The quantities to be paid for shall be the number of cubic meters calculated on theoretical designed lines and grades and the ground levels as established under clause 100.9, compacted in place, accepted by the Engineer formed with material resulting from:

i) Formation of Embankment from Borrow Excavation

Measurement shall be made as under:-

Formation from Borrow = Total Embankment Quantity (minus) Roadway excavation Quantity (minus) structural excavation Quantity.

ii) Formation from structural Excavation

This quantity shall be the same as calculated for structural excavation irrespective of its haulage distance except that declared unsuitable by the Engineer.

iii) Formation from Roadway Excavation.

This quantity shall be the same as calculated for Roadway Excavation. The contractor will be supposed to use material from Roadway Excavation irrespective of haulage distance. However if contractor, for his own convenience, uses the material from borrow, the payment will still be made under this item 108 (a) & 108 (b).

In the measurement of "Formation of Embankment on steep slopes" no allowance will be made for the benching or volume of material cut out from the hill side or from the first half width fill to accommodate the compacting equipment but will be calculated only on the net volume of fill placed against the original hill sides, the old embankment or the first half width fill.

108.4.2 Payment.

a) Formation from Borrow Excavation.

The quantity to be paid for shall be the number of cubic meters placed in embankment, measured as provided above for material from borrow excavation and such a payment will be deemed to include cost of excavation, borrow material, payment of royalty, levies and taxes of Local, Provincial and Federal Government, cost of hauling including lead and left up to 5km from project area, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

b) Formation from Structural Excavation.

The quantity to be paid for shall be the number of cubic meters placed in embankment and measured as provided above for material from structural excavation and such payment will be deemed to include cost of hauling, dumping, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item. Excavation for this item shall be paid separately.

c) Formation from Roadway Excavation

The quantity to be paid for shall be the number of cubic meters placed in embankment and measured as provided above for material from roadway excavation and such payment will be deemed to include cost of excavation, hauling, dumping, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
108 a	Formation of embankment from roadway excavation in common material	CM
108 b	Formation of embankment from roadway excavation in rock material	
	i. Hard rock (Compressive strength more than 100 MPa)	CM
	ii. Medium rock (Compressive strength 25MPa to 100 MPa)	CM
	iii. Soft rock (Compressive strength up to 25 MPa)	CM
108 c	Formation of embankment from borrow excavation in common material within 5-km from Project	CM
108 d	Formation of embankment from structural excavation in common material	CM
108 e	Formation of embankment from structural excavation in any type of rock material	CM

SECTION 109 SUBGRADE PREPARATION

109.1 DESCRIPTION

The subgrade preparation shall be that part of the work on which, the subbase is placed or, in the absence of subbase, act as the base of the pavement structure. It shall extend to the full width of the road bed including the shoulders and lay byes as indicated on the Drawings or as specified herein.

109.2 CONSTRUCTION REQUIREMENT

109.2.1 Prior Work

Before commencing the work all culverts, drains, ditches including fully compacted backfill over them outlets for drainage, head walls/wing walls of culverts and any other minor structure below thirty (30) centimeters of existing subgrade level or all structures which will be below thirty (30) centimeters of newly placed subgrade level, shall be in such operative conditions as to ensure prompt and effective drainage and to avoid damage to subgrade by surface water. No work of subgrade preparation will be started before the prior works herein described have been approved by the Engineer.

109.2.2 Compaction Requirement

All materials down to a depth of 30 cm below the subgrade level in earth cut or embankment shall be compacted to at least 95 percent of the maximum dry density as determined according to AASHTO T-180 Method 'B' or 'D' whichever is applicable, or corresponding Relative Density as per D-4254-83 (ASTM).

109.2.3 Subgrade Preparation in Earth Cut

In case bottom of subgrade level is within thirty (30) cm of the natural ground, the surface shall be scarified, broken up, adjusted to moisture content and compacted to minimum density of ninety five (95) percent of the maximum dry density as determined by AASHTO T-180 Method D. Subsequent layer of approved material shall be incorporated to ensure that the depth of subgrade layer is thirty (30) cm.

In case, the bottom of subgrade is below the natural ground by more than Thirty (30) cm, the material above the top of subgrade shall be removed and subsequent layer of thirty (30) cm shall be scarified, broken up, adjusted to moisture content and compacted to the same degree of compaction as described above.

In case, unsuitable material is encountered at the sub grade level within a depth of thirty (30) cm, the same shall be removed in total and replaced by the approved material. The contractor shall be paid for removal of unsuitable material as per pay Item 106a and for replacement of approved material, the payment will be made under pay Item 108c.

109.2.4 Subgrade Preparation in Rock Cut

Excavation in rock shall extend to the subgrade level as shown on drawings. Rock shall be undercut nearly to required elevation and sections shown on the plans or as directed by the Engineer. Transverse and longitudinal profiles checked by template shall be accurate to the requirement. Cuts below subgrade level shall be backfilled with selected subbase material and compacted to minimum ninety eight (98) percent of the maximum dry density as determined by AASHTO T-180, method 'D'. No compensation shall be made to the Contractor for over-cut or remedial measures as described above.

No rock shall be higher than two (2) centimeters above the undercut section elevation. The undercut material shall be placed in embankment or disposed of at the direction of Engineer.

109.2.5 Subgrade in Embankment

When the subgrade is formed in embankment, its width shall be the full width of top of embankment and material placed in the upper part of embankment down to a depth of thirty (30) centimeters below subgrade level shall meet compaction requirement of 109.2.2. Soils having a minimum value of C.B.R of seven (7) percent and swell value of not more than 0.3 percent shall be used. C.B.R less than seven (7) % may be used in case, the design allows for it. Unsuitable material if encountered within the existing formation layer as per laboratory specified test, shall be removed, disposed of and replaced by suitable one as per direction of the Engineer of which the payment will be made under relevant items of work.

Rollers and other equipments of approved size and type, accepted by the Engineer, shall be used for compaction. Water shall be added to obtain optimum moisture content; if necessary. Contractor shall ensure proper compaction in restricted areas by use of special equipments and rollers. No compensation shall be made for extra work due to restricted space.

Performance of this item of work shall not be paid for under this section but shall be deemed to be covered by the contract price for pay item 108a, through 108e, Formation of Embankment.

109.2.6 Subgrade Level in Existing Road

Where indicated on the Drawings or directed by the Engineer that the existing road surface is to be used as the subgrade, the correct elevation on which the base or subbase is to be laid shall be obtained, where necessary, either by means of leveling course or by excavation. The leveling course shall be constructed to the requirements of the Engineer and paid for under the appropriate Pay Item involved. Excavation shall include disposal of any surplus material in the adjacent embankment or elsewhere as directed by the Engineer.

In case, the design level of subgrade is within 30 cm of the existing ground/road then the item shall be measured and paid accordingly.

109.2.7 Subgrade reinforcement

When the width of the existing pavement, either to be scarified or not, is insufficient to contain the subbase or base to be placed upon it, the Engineer may order to strengthen and support the subbase or base on one or both sides of the existing pavement. This work shall consist of the removal and disposal of any unsuitable material and its replacements with suitable material to such width and depth as required by the Engineer.

The excavated material shall, if declared suitable for use elsewhere in the embankment by the Engineer be so used, and payment for its removal shall be covered under the contract price of Pay Item No. 108a; if declared unsuitable it shall be disposed of and paid as provided in Item 106a. The finished compacted surface of the subgrade shall be as specified in Item 109.2.3.

109.2.8 Protection of Completed Work

Any part of the subgrade that has been completed shall be protected and kept well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the subgrade. He shall repair any ruts or ridges occasioned by his own traffic or that

of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the area of subgrade preparation to an area easily maintained with the equipment available. Subgrade preparation and subbase or base placing shall be arranged to follow each other closely. The subgrade, when prepared too soon in relation to the placing of the sub base, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the subgrade as may be necessary to restore it to the state specified herein.

109.2.9 Templates and Straightedges

The Contractor shall provide for the use of the Engineer, satisfactory templates and straightedges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the subgrade levels have been checked and approved by the Engineer. For tolerances, referred to the, "Table for Allowable Tolerances" in these specifications.

109.3 MEASUREMENT AND PAYMENT

109.3.1 Measurement

The quantity to be paid for shall be the number of square meters of subgrade prepared as herein before prescribed and accepted. Subgrade in rock cuts and on embankment not consisting of the existing road surface in fill area shall not be measured for direct payment.

Subgrade preparation on "Existing Surface" shall only be measured for payment when ordered by the Engineer.

109.3.2 Payment

The quantities, determined as provided above, shall be paid for at the contract unit price respectively, for each of the particular pay items listed below that is shown in the Bill of Quantities which prices and payment shall be full compensation for furnishing of material, water, equipment, tools, labour, and all other items necessary for completion of work.

Pay Item No.	Description	Unit of Measurement
109 a	Sub grade preparation in earth cut area to required profile and camber of road and compaction up to 95% modified AASHTO for 300mm depth.	SM
109 b	Sub grade preparation in existing road without any fill to required profile and camber of road and compaction up to 95% modified AASHTO for 300mm depth.	SM

SECTION 110 IMPROVED SUBGRADE

110.1 DESCRIPTION

This work shall consist of the formation of the roadbed, under subbase or base course as the case may be, with an approved blend of materials, uniformly mixed, compacted, shaped and finished to the lines, grades and typical cross-sections shown on the Drawings, or in thickness as directed by the Engineer.

Improved subgrade as herein referred to may be defined as material suitable for embankment to which better quality of material is blended in proper proportion to improve its strength properties or performance.

110.2 MATERIAL REQUIREMENTS

The major component of improved subgrade shall consist of material conforming to Item 108.2 - "Material requirements for embankment."

The blending material shall be any soil that classifies as A-1 (a), A-1 (b), A-2-4 or A-3 according to AASHTO M-145 with PI of not more than 6.

The blended mixture when compacted to ninety five (95) percent of the maximum dry density determined by AASHTO T 180-D Method, shall exhibit a laboratory soaked CBR (96 hours) of not less than 20, or as specified in the drawings.

110.3 CONSTRUCTION REQUIREMENTS

110.3.1 Preparation

The surface of the roadbed on which the improved subgrade is to be constructed shall be compacted to the density specified under Item 108.3.1.

110.3.2 Proportioning of Materials

Prior to start of construction, the proportion of each material to be incorporated for improved subgrade shall be established as approved by the Engineer. The Engineer shall specify a single percentage of each material to be blended and shall establish the gradation of the resulting mixtures along with the ranges of permissible gradation tolerances to obtain the required CBR for the improved subgrade.

The blend proportions thus established shall apply only when each material to be used is obtained from same source. Should a change in source of material be made, a new proportion shall be established. When unsatisfactory results or other conditions make it necessary, the Engineer may require additional laboratory tests.

110.3.3 Mixing and Spreading

Improved sub grade may be constructed with any combination of machines or equipment that will yield results meeting these specifications.

a) Stationary Plant Method

The soil ingredients and water shall be mixed in an approved mixing plant (Pug Mill). The plant shall be equipped with feeding and metering devices that will add the materials to be blended in the specified quantities. Water shall be added during the mixing operation in the quantity required for proper compaction, which is approximately optimum moisture content plus or minus two (2) percent. The mixing time shall be that which is required to secure a uniform mixture. After mixing, the blended material shall be transported to the job site while it contains the sufficient moisture and shall be

placed on the roadbed by means of an approved mechanical spreader. The mixture shall be spread at rate that will produce a uniform compacted thickness conforming to the required grade and cross-section. Compaction shall start as soon as possible after spreading and shall continue until the specified relative compaction is achieved.

b) Traveling Plant Method

The traveling plant shall be either a flat transverse shaft type or a windrow type pug mill. After the materials have been placed by a mechanical spreader or windrow sizing device the materials shall be uniformly mixed by the traveling mixing plant. During the mixing operation, water shall be added as necessary to bring the moisture content of the mixture to the percentage suitable for proper compaction.

c) Road Mix Method

The materials shall be transported to the site and spread in layers on the roadbed in the quantities required to produce the specified blend. After the materials for each lift have been spread, the materials shall be mixed by motor graders and other approved equipment until the mixture is uniform throughout.

During mixing operation, water shall be added as necessary to bring the moisture content to the proper percentage.

110.3.4 Compaction

Unless otherwise permitted by the Engineer based on the performance of the compacting equipment used as determined from the trial section, each layer of improved sub grade shall be placed in horizontal layers of uniform loose thickness not exceeding twenty (20) centimeters. Each layer shall be compacted to the density conforming to the requirements specified in Item 108.3.1.

In-place density determinations of the compacted layers shall be made in accordance with AASHTO T-191, T-238 or other approved methods.

110.3.5 Trial Sections

Prior to the formation of the improved sub grade, the Contractor shall construct three trial sections of 200 meter length one (1) for each blend of improved material proposed to be incorporated for improved subgrade, or as directed by the Engineer. The compacting equipment to be used in the trial sections shall be the same equipment that the Contractor intends to use for main work, accepted by the Engineer.

The object of these trials is to determine the proper moisture content, the relationship between the number of passes of compacting equipment, density obtained for the blended material, and to establish the optimum lift thickness that can be effectively compacted with the equipment used. No separate payment will be made for this work, which will be regarded as a subsidiary obligation of the Contractor under pay Item No. 110.

110.3.6 Protection of Completed Work

Any part of the completed improved subgrade shall be protected and well drained and any damage shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the improved subgrade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the improved subgrade preparation to an area

easily maintained with the equipment available. Subgrade preparation and placement of succeeding layer to follow each other closely. The improved subgrade, when prepared too soon in relation to the placing of the layer above it, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the improved subgrade as may be necessary to restore it to the state specified herein.

110.3.7 Templates and Straightedges

The Contractor shall provide for the use of the Engineer, satisfactory templates and straightedges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the improved subgrade level have been checked and approved by the Engineer.

110.3.8 Tolerance

The allowable tolerances for the finished improved subgrade surface prior to placing the overlying subbase, base or asphaltic concrete course are given in the relevant, "Table for Allowable Tolerances" in these specifications.

110.4 MEASUREMENT AND PAYMENT

110.4.1 Measurement

The quantity of improved subgrade to be paid for shall be measured in cubic meter by the theoretical area covered in place as shown on the Drawings, completed and accepted improved subgrade in a thickness of 30 cms.

110.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter of improved subgrade for the pay item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, mixing, placing in layers, watering and compacting, labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
110 a	Improved sub grade	CM

SECTION 111 SOIL CEMENT STABILIZED SUBGRADE

111.1 DESCRIPTION

The work shall consist of performing all operations in connection with the formation of soil cement stabilized subgrade and all incidentals in accordance with the specifications and in conformity with the lines and level, grade and typical cross-sections shown on the plans or directed by the Engineer.

111.2 MATERIAL REQUIREMENTS

111.2.1 General

The mix in place method of construction shall only be applied to sites with naturally occurring sand, gravel or sand and gravel mixture. For the stationary plant method of construction the materials shall comply with the specifications or materials from any other source selected by the Contractor shall be subject to the Engineer's approval.

111.2.2 Soil

Soil used for cement stabilization shall be either "Silty or Clayey Soils" or sandy and gravely soils with the following characteristics

a) Silty and Clayey Soils

When this type of soil is used for cement stabilization it shall fulfill the following requirements.

i)	Liquid Limit (Max).	45%
ii)	Plastic Limit (Max).	20%
iii)	P.H. Value	Not less than 12
iv)	Soluble Sulphate Content max:	4%
v)	Soluble Chloride Content max:	8%

If the soil at site does not have P.H. value specified above, it shall be improved by adding calcium chloride upto two (2) percent by weight of the dry soil.

Soils, which don't meet above requirement, shall be subject to the approval of Engineer.

b) Sandy and gravely soils

Sandy and gravely soils used for cement stabilization shall fulfill the following requirements:

i)	Passing maximum size fifty (50) mm sieve	100%
ii)	Passing five (5) mm (No. 4) sieve	above 50%
iii)	Passing 0.4 mm (No. 36) sieve.	above 15%
iv)	Passing 0.075 mm (No. 200) sieve	below 5%
v)	Finer than 0.002 mm (Clay)	below 3%

Soils which do not meet above requirements shall be subject to the approval of Engineer after reviewing the laboratory testing results.

111.2.3 Cement

The Cement to be used for stabilization shall be Portland cement or sulphate resistant cement as directed by the Engineer according to the results of laboratory tests. Portland Cement shall conform to requirement of AASHTO M-85 while sulphate resistant cement shall conform to requirement of AASHTO M-74.

Immediately upon arrival to site, the Cement bags shall be stored in weather proof building to protect from dampness on raised platform. At the time of use, all cement shall be free flowing and free of lumps. Under normal circumstances cement shall not be stored for a period longer than four months. Any cement that has remained in store for a period in excess of four months, or of which there is any doubt as to its quality, shall be retested for specification requirements. No such cement shall be used in the works without the approval of Engineer.

111.2.4 Water

Water to be used shall be free from injurious quantities of oil, alkali, vegetable matter and salts. It shall not contain more than 1000 parts per millions of sulphates. In no case, water shall contain impurities to the extent that will cause change in setting time of cement by more than twenty five percent nor reduction in compressive strength of mortar after fourteen (14) days by more than five (5) percent when compared to results obtained with distilled water.

111.2.5 Mix Design Requirement in Laboratory

Before starting the work of stabilization, the proposed mix design showing exact percentage of cement and water to be used so as to obtain a mixture, shall be submitted by the contractor for the approval of Engineer. The mix proportions shall be such so as to satisfy the following requirements.

i) Mixture sample, stored in box, with maximum humidity of ninety five (95) % for twenty four (24) hours and submerged in water for two hours before crushing, shall have a minimum compressive strength of 17 kilogram per square centimeter.

ii) The maximum permissive swelling of volume shall be two (2) % and maximum loss in weight eight (8) % when tested in accordance with AASHTO T-135.

iii) Maximum permissible tolerance of cement and water content during construction shall be as under:-

Cement Content: Tolerance of $\pm$ 1.0 percent of that given in the mix design.
Water Content: 0 to (+)2% of that given in the mix design.

111.2.6 Composition of Mixture at Site

Soil shall be mixed with sufficient cement to obtain required crushing strength. The cement content shall be determined at the laboratory so that minimum compressive strength of mixture is thirty (30) Kg/square centimeter at seven (7) days. The moisture content of the mix cement stabilized material shall not be less than the optimum as determined by AASHTO T-134 Method and not more than two (2) percent above the optimum as determined by this test or such higher value as may be agreed by the Engineer on basis of preliminary trial.

111.3 CONSTRUCTION REQUIREMENTS

111.3.1 Mix in Place Method

The field equipments used for pulverizing and mixing the stabilized material shall be approved by the engineer on the basis of preliminary trials to ensure that the plant is capable of producing the required degree of mixing and uniformity of stabilized material to the full thickness of layer being processed. The mixers shall be equipped with a device for controlling the depth of processing and the mixing blades shall be maintained so that correct depth of mixing is obtained at all times. The cement shall be

spread ahead of mixer by means of a cement spreader, fitted with a device to ensure a uniform and controllable rate of spread of cement both transversely and longitudinally.

Water shall be added to adjust moisture content of material to optimum for compaction using water sprayer in uniform and controllable manner both transversely and longitudinally.

The mixing machine shall be set so that, it slightly cuts edge of adjoining lane processed previously to ensure proper processing of all material throughout the depth of layer. The output of the mixing plant shall not be less than twenty five linear meters per hour measured longitudinally of completed stabilized layer in order to achieve satisfactory compaction.

111.3.2 Stationary Plant Method

The stationary plant shall be of the power driven paddle or pan type and may be of the batch or continuous type. In case the batch mixes are used, the appropriate measured quantity of material and cement shall first be placed in the mixer and then water be added as necessary to bring the moisture content of the resulting mixture with in the range specified above.

Care shall be taken with batch type paddle mixers to ensure that the cement is spread uniformly in the loading skip so that it is fed evenly along the mixing trough and that with both paddle and pan mixers, the cement is proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilized. Mixing shall be continued until the mixture has the uniformity and mixing time will not be less than one (1) minute.

111.3.3 Compaction

Any modification to meet the specification shall be completed together with compaction, within one and a half (1 $^1/_2$) hours after mixing, or making good to deficient areas at contractor's expense. Thickness shall be as shown on the drawings or as directed by the Engineer and shall comply the following requirements.

Immediately after spreading and shaping operation, the mixture shall be thoroughly and uniformly compacted with approved rollers. Rolling shall continue until entire depth and width of subgrade is uniformly compacted to maximum density of Ninety five (95) % as tested in accordance with modified AASHTO T-134. Compaction shall be completed as soon as possible after mixing, normally within three hours, depending mainly on setting time of cement and weather conditions.

Compaction shall not be carried out after cement hydration and any soils material, which has been mixed or deposited after cement hydration, shall be removed and replaced with fresh mixed material.

After compaction, stabilized subgrade shall be protected against drying out by keeping it continuously damp or wet for a period of at least three (3) days or by coating with approved curing material. Surface shall be maintain in an acceptable condition at all times prior to the construction of sub-base.

No vehicular traffic shall run on the stabilized subgrade within a minimum curing period of seven days.

111.3.4 Tolerance

Tolerance in the thickness of compacted layers shall conform to as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

111.4 MEASUREMENT AND PAYMENT

111.4.1 Measurement

The unit of measurement for payment shall be cubic meter of completed and accepted subgrade as measured in place. Measurement shall not include any areas in excess of that shown on the drawings, except the areas authorized by the Engineer in writing. Measurement of cement content used shall be the number of metric Ton used to stabilize subgrade. This quantity of Cement consumed shall not exceed the theoretical percentage established in the laboratory.

111.4.2 Payment

The measured quantity of stabilized subgrade determined as above shall be paid for at the contract unit price per cubic meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment, handling, mixing manipulating, placing, shaping, compacting, including necessary water for compaction, rolling, finishing; correcting unsatisfactory areas and unsatisfactory material; maintenance including protection of stabilized layers; and incidentals necessary for completion of work except cement consumed which shall be paid separately as measured above.

SECTION 112 LIME STABILIZED SUBGRADE

112.1 DESCRIPTION

The work shall consist of performing all operations in connection with construction of lime stabilized subgrade and all incidentals in accordance with these specifications and in conformity with lines and level, grade and typical cross-sections shown on the plans or as directed by the Engineer.

112.2 MATERIAL REQUIREMENTS

112.2.1 Soil

Naturally occurring heavy clay soils, clayey gravels or soils containing a sufficient proportion of clay or silty clay to enable satisfactory stabilization with lime shall be required for the Mix in Place method of construction and shall conform to properties as specified in Item 111.2, "Material Requirements" under soils cement stabilized sub grade. Materials from any other sources selected by the Contractor shall comply with the specification all as approved by the Engineer in case of stationary plant construction method.

Lime stabilization has been used successfully in clayey soils having plasticity index more than ten (10). This type of stabilization is applicable to that soil which contains a high percentage of clay or silty clay.

112.2.2 Lime

Lime to be used for stabilization shall be calcium hydroxide (slaked or hydrated lime) or Calcium oxide (quick lime) to the requirements for building lime as in table 112-1 given below or lower quality lime produced from temporary burning pits or Kilns when approved by the Engineer.

Table 112-1: Specification Requirement for Lime

Property	LIME	
	Quick Lime (Ca O)	Hydrated Lime $Ca(OH)_2$
Calcium or Magnesium Oxides	Not less than 92%	Not less than 95%
Carbon Dioxide-at Kiln	Not more than 3%	Not more than 5%
Carbon Dioxide-elsewhere	Not more than 3%	Not more than 7%

112.2.3 Water

Water used for lime stabilization shall be clean and free from injurious substances. Potable water is preferred and organic water is not permitted. It shall neither contain more than 1,000 parts per million of chlorides nor more than 1,300 parts per million of sulphates (SO_4). Water from doubtful sources shall not be used until tested as specified in AASHTO- T-26 and approved by the Engineer.

112.2.4 Mix Design in Laboratory

The mix design shall be worked out in the laboratory and it shall state the following field requirements:

(i) The percentage of lime and water (optimum content and tolerances)

(ii) The field density of lime stabilized mixture to minimum ninety five (95) percent of laboratory density established with modified AASHTO T-134 test.

(iii) The required results of the compressive strength in laboratory at 7 days shall not be less than ten (10) Kg/sq. cm.

112.2.5 Composition of Mixture at Site

Soil containing clay shall be mixed with sufficient lime, normally three (3) percent to eight (8) percent lime content, so that minimum compressive strength is seven (7) Kilogram force per square centimeters at seven (7) days. Moisture content of the lime stabilized material shall be not less than the optimum nor more than two (2) percent above the optimum as determined by Vibrating Hammer method test of BS 1924 (1975).

As a guide trials, lime content should be established starting with 1% of lime by weight of dry soil for each ten (10) percent of clay in soil.

112.3 CONSTRUCTION REQUIREMENTS

112.3.1 Stationary Plant Method

The construction requirements of this clause shall conform to as specified in sub item 111.3.2.

112.3.2 Mix in Place Method

The requirements of construction under this clause shall be in accordance with sub item 111.3.1.

2.3.3 Precautionary Measures

Keeping in view the caustic nature of calcium oxide (quick lime), special measures shall be taken in handling, since it will attack equipment corrosively and precautions shall also be taken against the risk of severe skin burns to personnel. Suitable handling methods shall be used such as fully mechanized or bottom dump handling equipment, and protective clothing worn by the operators. Working operations should take into account the wind direction to minimize the dust problem and consequent eye or skin irritation to any personnel involved in the vicinity. Even when calcium hydroxide (slaked or hydrated lime) is used, care must be taken against the effects of prolonged exposure to skin.

112.3.4 Compaction Requirement

Immediately upon completion of spreading and shaping operation, the mixture shall be thoroughly compacted with approved roller. Compaction shall be continued until the entire depth of subgrade is uniformly compacted to the maximum density of 95% as determined by modified AASHTO T-134.

If quick lime is used, it shall not be permitted to compact the layers immediately after spreading the lime, because the hydration of the lime will cause damage to the compacted layers. The time within which compaction shall be completed will be

estimated in the laboratory. Dry density of compacted layers shall not be less than Ninety five (95) % of the maximum dry density determined in laboratory.

Compaction shall not take place after hydration of lime and any lime stabilized material that has been mixed and deposited after hydration of lime, shall be removed and replaced with fresh material, mixed and treated in accordance with the requirements of this clause.

Surface of subgrade shall be acceptable in all respects to specification, together with compaction with One and half (1.1/2) hours after mixing. Contractor will be responsible for any removal of or making good to deficient area without any extra payment. No vehicle or equipment shall be allowed to move over stabilized subgrade before initial setting of 7 days.

112.3.5 Tolerance

Tolerance for lime stabilized subgrade shall be as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

112.3.6 Weather Limitation

The laying of lime courses shall be avoided as far as practicable during cold and wet weather and shall be suspended when free standing water is present on the surface. The stabilized material shall not be laid on any surface, which is frozen or covered with ice or snow, and laying shall cease when the atmospheric temperature reaches five (5) degree C. on a falling thermometer or as directed by the Engineer. If wet weather threatens to be prolonged, the manufacture and laying of stabilized mix shall be suspended.

112.4 MEASUREMENT AND PAYMENT

112.4.1 Measurement

The unit of measurement for payment shall be the cubic meter of the compacted and accepted subgrade as measured in place. Measurement shall not include any area in excess of that shown on the drawings, except the areas authorized by the Engineer in writing. Measurement of lime consumed shall be the number of metric Ton used to stabilize subgrade. This quantity of lime consumed shall not exceed the theoretical percentage established in the laboratory.

112.4.2 Payment

The measured quantity of stabilized subgrade determined as above shall be paid for at the contract unit price per cubic meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment; handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance including protection of stabilized layers; and incidentals necessary for completion of work except lime consumed which shall be paid separately as measured above.

SECTION 113 BITUMEN STABILIZED SUBGRADE

113.1 DESCRIPTION

The work shall consist of performing all operations in connection with construction of bitumen stabilized subgrade and all incidentals in accordance with the specifications in conformity with the lines, grade, thickness and typical cross-sections shown on the plans or as directed by the Engineer.

113.2 MATERIAL REQUIREMENTS

113.2.1 Soil

This method will only apply to sites with naturally occurring non plastic material such as sand. If the material is brought at site, it shall be non-plastic having uniform gradation.

113.2.2 Bitumen

Bituminous material used for subgrade stabilization shall comply with the requirement as per relevant tables specified in item 301, "Asphaltic Materials" for hot mix asphaltic concrete or can be viscous cut back that requires heating in areas where moisture content of sand is high, necessitating heating and drying of sand.

In dry areas, where natural moisture content of sand is low, the bituminous binder shall be fluid cut back conforming the requirements as given in tables 301-3 and 301-4 respectively of item 301 "Asphaltic Materials".

Bitumen emulsion or foamed penetration grade bitumen can also be used subject to the approval of Engineer after trial test.

Bitumen-sand mixture for the grade of bitumen selected shall be ascertained by trial mixes using Marshall Test to determine the quantity of bitumen required using either heated or unheated sand. The quantity of bitumen required will generally lie between three (3) to six (6) percent by weight of dry sand, the higher proportions being required with fine-grained materials.

113.3 CONSTRUCTION REQUIREMENTS

Equipment, tools, and machines used for bitumen stabilized subgrade shall be subject to the approval of Engineer and shall be maintained in satisfactory working conditions all the times.

Mix in place method of bitumen stabilization will be subject to the approval of Engineer to ensure full control of bitumen content, uniform and thorough mixing and satisfactory processing of the material to the full depth of the layer. For scarification of in situ material and spreading of bituminous material, grader with blade and bitumen distributor shall be used The stabilized soil shall be left uncompacted after pulverization and mixing to allow for evaporation of volatile materials thus increasing stability and decreasing water absorption particularly in fine grained sand when temperature is low.

113.3.1 Compaction

Immediately after completion of spreading, aeration and shaping operation, the mixture shall be thoroughly compacted with rubber or pneumatic tyred rollers. Compaction shall continue until entire width and depth of subgrade is uniformly compacted to give soaked (96 hours) unconfined compressive strength according to design requirement to meet traffic loading. Steel wheeled tandem roller shall be used to carry out final rolling of compacted surface to eliminate the tyre marks.

To determine the efficiency of mixing, spreading, degree of compaction of equipment and suitability of construction method, trial sections as directed by the Engineer, shall be prepared by the contractor before main work of stabilization is started.

If thickness of compacted layer is less than 20 centimeters, it shall be laid as single operation where as if thickness of compacted stabilized layer is more than twenty centimeter, material shall be placed in two or more layers, each within the range of eight (8) to twenty (20) centimeters in compacted thickness.

The results of CBR test for measuring the strength of bitumen stabilized materials or cone stability test for designing bitumen-sand mixture shall not supersede those of Marshall Test unless agreed by the Engineer. In-situ density of compacted layer shall be determined using method as described by AASHTO - T-191, AASHTO - T-205 or AASHTO - T-238 and shall be minimum ninety five (95) % modified AASHTO according to the above mentioned methods.

Frequency of testing in field and in laboratory will be according to relevant schedule for sampling and testing of these specifications.

113.3.2 Tolerance

Compacted layer shall comply with the tolerance requirements as specified in relevant, "Table for Allowable Tolerances" in these specification.

113.3.3 Weather Limitation

The laying of bituminous courses shall be avoided as for as practicable during wet weather and shall be suspended when free standing water is present on the surface. The stabilized material shall not be laid on any surface, which is frozen or covered with ice or snow and laying shall cease when the air temperature reaches five (5) degree C on a falling thermometer. Laying shall not commence until the air temperature is at least five (5) degree C on a rising thermometer unless otherwise directed by the Engineer and also if wet weather threatens to be prolonged the manufacture and laying of stabilized mix shall be suspended.

113.4 MEASUREMENT AND PAYMENT

113.4.1 Measurement

The unit of measurement for payment shall be cubic meters of a given thickness of compacted and accepted subgrade as measured in place. Measurement shall not include any areas in excess of that shown on the drawings, except the areas authorized by the Engineer in writing. Measurement of bitumen binder used shall be the number of metric Ton used to stabilize subgrade. This quantity of bitumen consumed shall not exceed the theoretical percentage established in the laboratory.

113.4.2 Payment

Measured quantity of stabilized subgrade determined as above shall be paid for at the contract unit price per cubic meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment; handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsuitable areas and unsatisfactory material; maintenance including protection of stabilized subgrade layer and incidentals necessary for completion of work except bitumen consumed which shall be paid separately as measured above.

SECTION 114 DRESSING AND COMPACTION OF BERMS

114.1 DESCRIPTION

This work shall consist of scarification of berms, which are undulated, or out of level. The existing material shall be scarified, watered, mixed and properly leveled and compacted according to specification described here under or as directed by the Engineer.

114.2 MATERIAL REQUIREMENTS

In this item no fresh material is required, however, if fresh material is used it shall be measured and paid under other relative items of works.

114.3 CONSTRUCTION REQUIREMENTS

114.3.1 Dressing of berm without the use of extra material

In case the berms show undulation of more than 5 cms in level from the reconstructed pavement structure, the berms shall be scarified to a depth of 15 cm and material will be watered, mixed and compact with appropriate equipment approved by the Engineer.

114.3.2 Dressing of berm with the use of extra material

In case the difference of elevation of existing berm with respect to reconstructed road structure is less then 15 cm then additional material (to be measured under other items of work) shall be added to bring the level of berms in conformity with the lines and grades of the existing road. Existing and fresh material shall be properly mixed, watered and compacted as directed by the Engineer.

114.3.3 Compaction requirement

Compaction requirement of the fresh and existing material shall be in accordance with the type of material used in berms, as under:-

Depth in cm	Compaction requirement as per AASHTO T-180 (D).
0 - 15 (Top layer)	95% for common earth material
0 - 15 (Top layer)	100% for subbase material

114.3.4 Compaction of slopes

While reinstating/dressing of berms, it shall be ensured that compaction requirements are observed on slopes of the berms. The degree of compaction shall be as per direction of the Engineer.

114.4 MEASUREMENT AND PAYMENT

114.4.1 Measurement

Measurement under this item shall be made in square meter of berms dressed or compacted in accordance with theoretical lines, or sections shown on the drawings, or as per existing edge of road.

In case partial fresh material is used to compensate for shortage of material in the top layer the quantity of such material shall be measured by survey levels of existing ground and designed lines, grades or sections shown on the drawing.

The quantity of material thus measured shall be paid under other items of works of formation of embankment / subbase.

114.4.2 Payment

The payment of this item shall be made for at the contract unit price per square meter of dressed and compacted berm measured as above, for scarification watering, mixing, rolling, labour, equipment, tools and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
114 a	Dressing of berm without extra material	SM
114 b	Dressing of berm with extra material	SM

SECTION 115 REINSTATEMENT OF SHOULDERS FROM BRICK KILN MATERIAL

115.1 DESCRIPTION

This work shall consist of furnishing and placing in single layer of Brick Kiln material on shoulders and to mechanically interlock by watering and rolling, in conformity with lines, grades and cross-sections shown on drawing.

115.2 MATERIAL REQUIREMENTS

The material shall conform to the following requirements.

115.2.1 Texture

The Kiln material shall be fully burnt having reddish brown/black colour. No unburnt or semi burnt material shall be allowed. The material shall behave like improved sub grade with following properties.

115.2.2 Gradation

The grading shall conform to the following limits.

Sieve Designation		Mass Percent Passing.
1"	(25 mm)	100
3/8"	(9.5 mm)	80-100
No. 10		50-85
No. 200		15-35

Note:- Coarser than 1" (25 mm) size material may be allowed upto five (5) percent by the Engineer.

115.2.3 Physical Requirements

The additional physical requirements of the kiln material will satisfy the following limits:-

1.	P.I. value.	6.0% max.
2.	Swelling Value.	0.20% max.
3.	Soaked C.B.R. (96 hours)	20% min.

115.3 CONSTRUCTION REQUIREMENTS

115.3.1 General

Material for shoulders, obtained and approved as provided above shall be placed and thoroughly mixed with water in horizontal layer of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings. The layer of loose material shall not be more than twenty (20) centimeters in thickness unless otherwise approved by the Engineer.

The compaction of the shoulders shall be carried out at the designated moisture content, consistent with the approved compacting equipment. Shoulder material that does not contain sufficient moisture to obtain the required compaction shall be given additional moisture by means of approved sprinklers and mixing operation.

Material containing moisture more than necessary to obtain the required compaction may not, without written approval of the Engineer be incorporated in the shoulders until it has been sufficiently dried out. The drying of wet material may be expedited by discing or other approved methods.

Side slopes shall be neatly trimmed to the lines and slopes shown on the drawings or as directed by the Engineer, and the finished work shall be kept in a neat and acceptable condition.

115.3.2 Compaction

All material shall be compacted to a minimum ninety five (95) percent of the maximum dry density as determined according to AASHTO T-180 method 'B' or 'D' whichever is applicable. In place density determination of the compacted layer shall be made in accordance with AASHTO T-191 or other approved method.

115.4 MEASUREMENT AND PAYMENT

115.4.1 Measurement

The quantities to be paid for shall be the number in cubic meter by the theoretical volume of shoulders constructed according to designed lines and grades compacted in place and complete in all respect.

115.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter of Brick Kiln shoulder material for the pay item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, mixing, placing, watering and compacting, labour, equipment, tools and incidentals necessary to complete the item.

ITEM 116 REINFORCED SOIL SLOPE (RSS)

116.1 DESCRIPTION

This work shall consist of preparing the design, furnishing the materials, and constructing the reinforced soil slope (RSS) to the lines, grades and dimensions shown in the contract plans, this special provision, any additional requirements specified by the RSS system supplier in the approved shop drawings and as directed by the Engineer.

116.2 MATERIAL REQUIREMENTS

The RSS materials shall conform to the IDOT Standard Specifications, the supplier's standards, and the following:

(a) The soil reinforcement shall be manufactured from high density polyethylene (HDPE) uniaxial, polypropylene (PP) biaxial resins, or high tenacity polyester (PET) fibers that can develop the Long-Term Allowable Strength and Pullout Resistance required per the Contractors approved design. The soil reinforcement shall be stored between -20 and 140 degrees F (-29 and 60 degrees C). The following standards shall be used to determine the soil reinforcement design properties:

ASTM D 638	Tensile Properties of Plastic
ASTM D 1238	Melt Flow (HDPE and PP)
ASTM D 1248	Molding and Extrusion (HDPE)
ASTM D 1505	Specific Gravity (HDPE)
ASTM D 4218	Carbon Black Content (HDPE)
ASTM D 2455	Carboxyl End Group (PET)
ASTM D 4603	Intrinsic Viscosity (PET)
ASTM D 5262	Unconfined tension Creep Behavior of Geosynthetics
GRI:GG1	Geogrid Rib Tensile Strength
GRI:GG2	Geogrid Junction Strength
GRI:GG4	Long Term Design Strength of Geogrid
GRI:GG5	Evaluating Geogrid Pullout Behavior

(b) Steel reinforcement and tie strips shall be hot dipped galvanized and shall comply generally with ISO 1460 & 1461.

i. Tie strips shall be plain flats of Grade 250 or as specified in the drawing.

ii. Reinforcement strips shall be ribbed flats of Grade 350 or as specified in the drawing.

Reinforcement strips shall be cut to length and holed in the specified locations. Reinforcement shall be inspected to ensure that it is free from defects that may impair its strength or durability.

No plastic material shall be used as reinforcement for permanent structures.

(c) The Facing treatment shall be either vegetated or hard armored facing, as specified on the plans.

The vegetated facing treatment materials shall include any top soil, compost, seeding, sod, erosion controls, watering provisions, or other vegetative systems (all according to the Standard Specifications).

Hard armored facing may consist of steel facing panels, gabions, wire mesh baskets, geocell, riprap, precast RCC elements or other articulated units shown on the plans. The infill for hard armored facing shall be either vegetation soil or coarse aggregate, as shown on the plans, or if not specified as per the suppliers written specifications.

(d) Steel facing panels shall be cold formed sections of specified profile and thickness generally complying with AS3679.

Facing panels shall be cut to length and holed in the specified locations and shall include joint cover strips as specified.

(e) The RSS fill, defined as the material placed within the soil reinforcement limits for the RSS system (excluding facing treatment), shall be in accordance with the following specifications:

(1) It shall have 100% passing the ¾ in. (19mm) sieve and a maximum 35% passing the #200 (75 micron) sieve, as determined according to AASHTO T-88.

(2) For non-granular (cohesive) material, the liquid limit (LL) shall not exceed 50 and the plasticity index (PI) shall not be less than 12.

(3) It shall have a minimum Standard Dry Density of 90 lb/ft^3 (1442 kg/m^3) when tested according to AASHTO T 99, and shall not have an organic content greater than 10 percent when tested according to AASHTO T 194.

(4) The material shall not be compacted at moisture content in excess of 110 percent of the optimum moisture content as determined according to AASHTO T 99.

(5) It shall have an in place compacted minimum cohesion of 1000 psf (48 kPa) or a minimum friction angle of 30 degrees.

(6) Soundness shall be class C quality or better according to AASHTO T 104 for any fine or course aggregates used.

(7) pH shall be no less than 3 for PP and HDPE soil reinforcement or between 3 and 9 if PET soil reinforcement is used.

Prior to placing the embankment fill, the source material shall be approved by the Engineer and in-place samples may be tested to ensure that the material meets the above requirements.

(f) Filler for the vertical joints shall be flexible open cell polyurethane foam strips of 40mm square cross section with density not less than 20 kg/m3.
For the horizontal joints the filler shall be:

Either (i) Resin bonded cork filler board conforming to ASTM D 1752

Or (ii) Rubber pad with shore hardness 85 +0, -5.

(g) Bolts and nuts shall be strength Grade 8.8 to BS 3692 or equivalent, metric size M 12 with hot dip galvanized or equivalent protective coating. The galvanization shall comply with ISO 1460 & 1461.

116.3 CONSTRUCTION REQUIREMENTS

The Contractor shall obtain technical assistance from the supplier during slope erection to demonstrate proper construction procedures and shall include any costs related to this technical assistance in the unit price bid for this item.

(a) *Site Preparation:* The foundation soils supporting the RSS shall be graded for a width equal to the length of the lowest soil reinforcement length. Cut slope surfaces shall be benched to allow the RSS to be keyed into the existing retained embankment. Prior to soil reinforcement placement, the foundation soils shall be

compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced, as directed by the Engineer.

Water shall be diverted from the area where soil reinforcement is being placed and soil is being compacted. Diversion shall be performed using a method approved by the Engineer.

(b) *Soil Reinforcement:* At each soil reinforcement level, the RSS fill material should be roughly leveled and compacted before placing the soil reinforcement. Reinforcement placement shall be installed in accordance with the manufacturer's recommendations and as shown on the approved shop drawings. The reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. Joints or splices will only be allowed if detailed in the approved shop drawings.

Place only that amount of reinforcement required for immediately pending work to prevent undue damage. After a layer of soil reinforcement has been placed, the next succeeding layer of RSS fill shall be placed and compacted. After the required facing treatment is installed and a series of RSS fill lifts are placed to the next level of soil reinforcement, the next soil reinforcement layer shall be installed and the process shall be repeated until the RSS height is completed. Soil reinforcement layers shall be laid flat, pulled tight prior to backfilling, and held in place with pins or other methods. Each soil reinforcement layer shall be placed to within 3 inches (75 mm) of that shown on the shop drawings.

(c) *RSS Fill Placement:* RSS fill within the soil reinforcement shall be placed and compacted as specified. The embankment shall be compacted to at least 95percent of the maximum density determined in accordance with AASHTO T-99. A minimum of one density test every 3 ft. (0.9 m) lift of fill will be performed by the Engineer. RSS fill shall be placed, spread, and compacted in such a manner to avoid the development of wrinkles and/or displacement of the soil reinforcement. Where retained embankment must be placed behind the RSS, its placement shall closely follow placement of the RSS fill.

RSS fill and retained embankment shall be graded away from the slope crest and rolled at the end of each work day to prevent ponding of water on surface of the reinforced soil mass.

A minimum fill thickness of 6 in. (150 mm) is required prior to operation of tracked vehicles over the reinforcement and turning of tracked vehicles should be kept to a minimum to prevent displacing the soil reinforcement. If approved by the Engineer, rubber-tired equipment may pass over the reinforcement at speeds of less than 5 mph. Sudden braking and sharp turning shall be avoided. No rubber-tired wheel traffic will be allowed in direct contact with coated geosynthetic geogrid, as damage to the coating could result.

Compaction adjacent to the backside of the facing treatment shall be achieved by use of light weight mechanical tampers, rollers, vibratory system or other methods to provide short and long term erosion and facing stability.

(d) *Facing Treatment:* For vegetated slope facing, the construction of any top soil, compost, seeding, sod, mulching, erosion controls, watering shall be as per instructions shown in the approved shop drawings.

For hard slope facing, the construction of any gabions, wire mesh baskets, geocell, coarse aggregate, riprap, precast elements or other articulated units shall be according to the standard specifications provided by the material supplier unless otherwise specified in the approved shop drawings.

116.5 MEASUREMENT AND PAYMENT

116.5.1 Measurement

For measurement purpose, the reinforced soil slope work will be split into three parts: steel reinforcement and tie strips, facing panels and granular backfill. Steel reinforcement and tie strips will be measured in the units of length whereas facing panels will be measured in the units of area. Granular backfill will be measured and paid as per item 107.4 of this General Specification.

116.5.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay Items listed below and shown in the Bill of Quantities which prices and payment shall constitute full compensation for all costs involved in the proper completion of the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
116 a	Soil Reinforcement and Tie Strips	LM
116 b	Facing Panels	SM
116 c	Granular Backfill type--	CM

SUB BASE
AND
BASE

SUBBASE AND BASE

SECTION 200 G E N E R A L

200.1 DESCRIPTION

The work shall consist of furnishing, spreading, and compacting graded sub base, base, asphaltic base course, crushed limestone base course, cement stabilized sub base and base course, lime stabilized sub base and bitumen stabilized sub base and base, crack relief layers, constructed on a prepared bed and all incidentals in accordance with these specification in conformity with the lines, grade thickness and typical cross-section shown on the drawing and/or as directed by the Engineer.

200.2 MATERIAL

The material shall consist of sand, gravel or a sand gravel mixture obtained from the source approved by the Engineer. Material requirements for this work are specified under various items of the section.

200.2.1 Sampling and Testing

Adequate representative samples shall be submitted to Engineer for testing and preliminary approval not less than twenty days, before the intended material is to be used in the work. The material, when deemed necessary by the Engineer, shall be sampled and tested in his presence by the contractor for particular sub base, base course as called for in the specification of particular application and /or the bill of quantities, and/or as shown on the drawing, to assure conformance with the requirements of specification. Any material found not to conform with the requirements will be subject to rejection. All rejected material shall be removed and replaced with the material meeting the requirement, at no additional cost to the Client.

Preliminary approval of source shall not mean that all the material in the source is approved.

Sampling and testing, unless otherwise stated, shall be according to the standard methods prescribed in the latest edition of the American Association of State Highway and Transportation Officials (AASHTO) or standard specification and methods of sampling and testing, provided in latest version of American Society of Testing and Materials (ASTM). Any deviation from the methods and procedure prescribed therein may be made only as directed in writing by the Engineer as per relevant "Table for Sampling and Testing Frequency".

200.2.2 Selection of Place for Sampling

The selection of representative samples for testing shall be by "Random Sampling Method" by which every part of a lot or stockpile has equal chance to be selected. When it is necessary to sample stockpiles, every effort should be made to enlist the service of power equipment that is capable of exposing the material at various levels and locations. In sampling sand from stockpiles, the outer layer which may have become dry, causing segregation shall be removed and representative samples of the damp sand selected.

200.2.3 Number and Size of Samples

The number and size of sample required depends on the intended use of the material, the quantity of material involved and the variation both in quality and size of aggregate. A sufficient number of samples shall be obtained to cover all variations in the material. The quantities must be sufficient to provide for proper execution of the required tests.

200.2.4 Schedule for Sampling and Testing

The sampling frequency, acceptance limits, and other information for proper control of each work shall be as given in "Tables for Sampling and Testing Frequency" which will provide the minimum testing frequency under normal conditions. Where sampling frequencies are not given in the table they shall be as directed by the Engineer. Where frequencies are given as per layer or per strip this will mean the width of strip or layer being laid at any one item. If the materials or operations are variable and good control is difficult to maintain, greater sampling frequency may be taken as directed by the Engineer.

200.2.5 Tolerances

The allowable tolerances for the subgrade prior to placing the overlying courses, together with the allowable tolerances for the sub base and base are as specified in "Table for Allowable Tolerances", in these specifications.

200.3 PLANT & EQUIPMENT

All equipment, tools and machines used in the performance of work shall be maintained in satisfactory conditions at all times and be subject to the approval of the Engineer. List of recommended type of equipment is only for guidance of contractor. However, contractor will be responsible to give required quality and workmanship through any type of equipment irrespective of any approval given by the Engineer.

200.4 TRIAL STRIPS

Contractor shall prepare trial strip for any item as appearing in this chapter, to establish the following.

a) Maximum thickness of loose layer, which can be laid.

b) Type of equipment to be used.

c) Watering and mixing procedures.

d) Number of passes required to satisfactorily compact the layer to required level.

e) Any other requirement ordered by the Engineer.

Engineer shall then inspect and test the Trial Strip and approve the procedure in writing, to carry out the work. However, this approval shall not relieve the contractor from his contractual obligation.

SECTION 201 GRANULAR SUBBASE

201.1 DESCRIPTION

This item shall consist of furnishing, spreading in one or more layers and compacting granular sub base according to the specifications and drawings and/or as directed by the Engineer.

201.2 MATERIAL REQUIREMENTS

Granular sub base material shall consist of natural or processed aggregates such as gravel, sand or stone fragment and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable sub base.

The material shall comply to the following grading and quality requirements:

a) The sub base material shall have a gradation curve within the limits for grading A and B given in table 201-1 below. However grading A may be allowed by the Engineer in special circumstances.

Table 201-1: Grinding Requirements for Sub base Material

Sieve Designation		Mass Percent Passing Grading	
mm	Inch	A	B
60.0	(2.1/2)	100	--
50.0	(2)	90-100	100
25.0	(1)	50-80	55-85
9.5	(3/8)	--	40-70
4.75	No. 4	35-70	30-60
2.0	No. 10	--	20-50
0.425	No. 40	--	10-30
0.075	No. 200	2-8	5-15

The Coefficient of Uniformity D60/D10 shall be not less than 3, where D60 and D10 are the particle diameters corresponding to 60% and 10%, respectively, passing (by weight) in a grain size analysis, curve.

b) The Material shall have a CBR value of at least 50%, determined according to AASHTO T-193. The CBR value shall be obtained at a density corresponding to Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.

c) The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent.

d) In order to avoid intrusion of silty and clayey material from the sub grade in the sub base, the ratio D15 (Sub base)/D85 (Sub grade) should be less than 5.

Where D85 and D15 are the particle diameters corresponding to eighty five (85) % and fifteen (15) %, respectively, passing (by weight) in a grain size analysis, curve.

e) The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two third of the fraction passing the 0.425 mm (No. 40) sieve. The fraction passing the 0.425 mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.

f) If over-size is encountered, screening of material at source, shall invariably be done, no hand picking shall be allowed, however hand picking may be allowed by the Engineer, if over-size quantity is less than 5% of the total mass.

g) Sand equivalent for all classes shall be 25 min.

201.3 CONSTRUCTION REQUIREMENTS

201.3.1 Spreading

Granular sub base shall be spread on approved subgrade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

Granular sub base shall be deposited on the roadbed or shoulders in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the sub base material. In case any material is to be added to compensate for levels, the same shall be done after scarifying the existing material, to ensure proper bonding of additional material.

When the required thickness is fifteen (15) cm or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than seven and one half (7.5) centimeters thick. Where the required thickness is more than 15 cm, the aggregates shall be spread and compacted in 2 or more layers of approximately equal thickness, but in any case the maximum compacted thickness of one layer shall not exceed 15 cm. All subsequent layers shall be spread and compacted in a similar manner.

Granular sub base shall be spread with equipment that will provide a uniform layer conforming to the specified item both transversely and longitudinally within the tolerances as specified in "Table for Allowable Tolerances" in these specifications. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operation will cause cutting or rutting of subgrade or contamination of sub base material.

201.3.2 Compaction Trials

Prior to commencement of granular sub base operation, contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the approved sub base material as will be used during construction to determine the adequacy of the contractor's equipment, loose depth measurement necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material. For details, refer to clause 1.20 (General) of these specifications.

201.3.3 Compaction

The moisture content of sub base material shall be adjusted prior to compaction, by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the specified compaction.

The sub base material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyred rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on super elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. While the rolling progresses, the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain a smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density.

Any area inaccessible to rolling equipment shall be compacted by means of hand guided rollers, plate compactors or mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of sub base material or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and recompact the material before succeeding layer of the pavement structure is constructed.

Immediately prior to the placing of first layer of base course the sub base layer (both under the traveled way and the shoulders) shall conform to the required level and shape. Prior to placing the succeeding layers of the material, the top surface of each layer shall be made sufficiently moist to ensure bond between the layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the plans.

No material for construction of the base shall be placed until the sub base has been approved by the Engineer.

201.3.4 Compaction requirements

The relative compaction of each layer of the compacted sub base shall not be less than Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D. The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used

201.3.5 Moisture Content Determination

As it is customary in the project laboratories that small samples of materials are placed in ovens for moisture determination for proctor, following precautions are necessary to ensure proper compaction results.

a) Same size of sample is placed in oven for moisture determination in case of laboratory density (Proctor) and field density.

b) Moisture content for calculation of field density and proctor shall be observed on material passing 4.75 mm sieve.

201.3.6 Tolerance

The sub base shall be compacted to the desired level and cross slopes as shown on the drawings. The allowable tolerance shall be according to the "Table for Allowable Tolerances" in these specifications.

201.4 MEASUREMENT AND PAYMENT

201.4.1 Measurement

The quantity of sub base to be paid for shall be measured in cubic meters by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed granular sub base course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross-sections.

201.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter of granular sub base, for the Pay Item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
201 a	Providing and laying Granular sub base in approved thickness as per profile and camber of road including watering and compaction to 98% modified AASHTO.	CM

SECTION 202 AGGREGATE BASE COURSE

202.1 DESCRIPTION

This item shall consist of furnishing, spreading and compacting one (1) or more layers of aggregate base on a prepared sub grade, sub base, or existing road surface, in accordance with the specifications and the drawings and/or as directed by the Engineer.

202.2 MATERIAL REQUIREMENTS

Material for aggregate base course shall consist of crushed hard durable gravel, rock or stone fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm, stable base for both flexible and rigid pavements.

The aggregate base shall comply to the following grading and quality requirements.

a) The gradation curve of the material shall be smooth and within the envelope limits for Grading A or B given below in table 202-1.

Table 202-1: Grinding Requirements for Aggregate Base Material

Sieve Designation		Mass Percent Passing Grading	
mm	Inch	A	B
50.0	2	100	100
25.0	1	70-95	75-95
9.5	3/8	30-65	40-75
4.75	No. 4	25-55	30-60
2.00	No. 10	15-40	20-50
0.425	No. 40	8-20	12-25
0.075	No. 200	2-8	5-10

The material shall be well graded such that the coefficient of Uniformity D60/D10 shall be greater than four (4).

b) Crushed Aggregate (material retained on sieve NO. 4) shall consist of material of which at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

c) The Coarse aggregate shall have a percentage of wear by the Loss Angeles Abrasion test (AASHTO T-96) of not more than forty (40).

d) The material shall have a loss of less than twelve (12) percent when subjected to five cycles of the Sodium Sulphate Soundness test according to AASHTO T-104.

e) The sand equivalent determined according to AASHTO T-176 shall not be less than 45 and the material shall have a Liquid limit of not more than twenty five (25) and a plasticity Index of not more than 6 as determined by AASHTO T-89 and T-90.

f) The material passing the 19 mm sieve shall have a CBR value of minimum eighty (80) percent, tested according to the AASHTO T 193. The CBR value

shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.

g) Laminated material shall not exceed 15% of total volume of Aggregate Base Course.

202.2.1 Filler for Blending

If filler, in addition to that naturally present in the aggregate base material is necessary for meeting the grading requirement or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the crushing plant or in a pugmill unless otherwise approved. The material for such purpose shall be obtained from sources approved by the Engineer. The material shall be free from organic matter, dirt, shale, clay and clay lump or other deleterious matter and shall conform to following requirement.

AASHTO Sieve	Percent Passing
3/8 Inch	100
4	85-100
100	10-30
Plasticity Index (AASHTO T-90)	6 maximum
Sand Equivalent (AASHTO T-176)	30 minimum

However the combined aggregates prepared by mixing the coarse material and filler shall satisfy the requirements as mentioned in clause 202.2 above.

202.3 CONSTRUCTION REQUIREMENTS

202.3.1 Preparation of surface for Aggregate base course

In case crushed aggregate base is to be laid over prepared sub base course, the sub base course shall not have loose material or moisture in excess to optimum moisture content.

Spreading shall conform in all respects to the requirements specified under this heading in Item 201 – Sub base (201.3.1).

202.3.2 Compaction

Compaction process shall conform in all respect to the requirements specified under this heading in Item 201 (201.3.3).

202.3.3 Compaction Requirement

The relative compaction of each layer of the compacted base shall not be less than 100 percent to the maximum dry density determined according to AASHTO T-180, Method D (Modified). The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used

Completed base course shall be maintained in an acceptable condition at all times until prime coat is applied. When base course is to carry traffic for an indefinite length of time before receiving surfacing, the contractor shall maintain the surface until final acceptance and shall prevent reveling by wetting, blading, rolling and addition of fines as may be required to keep the base tightly bound and leave a slight excess of material over the entire surface which must be removed and the surface finish restored before application of prime coat.

202.3.4 Moisture Content Determination

Moisture content determination shall conform in all respects to the requirements specified under clause 201.3.5 for sub base.

202.3.5 Trial Sections

Prior to commencement of aggregate base course operations, a trial section of two hundred (200) meters minimum, but not to exceed five hundred (500) meters shall be prepared by the contractor using same material and equipment as will be used at site to determine the adequacy of equipment, loose depth measurement necessary to result in the specified compacted layer depths, field moisture content, and relationship between the number of compaction passes and the resulting density of material. For details refer to clause 1.20 (General) of these specifications.

202.3.6 Tolerance

The completed base course shall be tested for required thickness and smoothness before acceptance. Any area having waves, irregularities in excess of one (1) cm in three (3) M or two (2) cm in fifteen (15) M shall be corrected by scarifying the surface, adding approved material, reshaping, re-compacting and finishing as specified. Skin patching of an area without scarifying the surface to permit proper bonding of added material shall not be permitted. The allowable tolerances shall be according to the "Table for Allowable Tolerances" in these specifications.

202.3.7 Acceptance, Sampling and Testing

Acceptance of sampling and testing with respect to materials and construction requirements shall be governed by the relevant, "Table for Sampling and Testing Frequency" or as approved by the Engineer.

202.4 MEASUREMENT AND PAYMENT

202.4.1 Measurement

The quantity of aggregate base to be paid for, shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed crushed aggregate base course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross sections.

202.4.2 Payment

The accepted quantities measured as above shall be paid for at the contract unit price per cubic meter of aggregate base, for the item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
202 a	Providing and laying crushed stone aggregate base course in approved thickness as per profile and camber of road including watering and compaction to 100% modified AASHTO.	CM

SECTION 203 ASPHALTIC BASE COURSE PLANT MIX

203.1 DESCRIPTION

This work shall consist of furnishing of plant, labour, equipment and material and performing all operations in connection with the construction of an asphaltic plant-mix base course on a previously constructed and accepted sub grade, sub base or base course, subject to terms and conditions of the Contract, and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer.

203.2 MATERIAL REQUIREMENTS

203.2.1 Mineral Aggregate

Mineral aggregate for bituminous base course shall consist of coarse aggregate, fine aggregate and filler material, if required, all conforming with the following requirements:

Coarse aggregate which is the material retained on AASHTO No. 4 sieve shall consist of crushed rock, crushed gravel or crushed boulder. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shale, clay lump or other deleterious substances. Rock or boulders from which coarse aggregate is obtained, shall be of uniform quality throughout the quarry.

The crushing shall be so regulated that at least ninety five (95) percent by weight of material retained on AASHTO No. 4 sieve shall consist of pieces with at least two (2) mechanically fractured faces, and when tested for stability of bituminous mix shall show satisfactory stability.

Fine aggregate which is material passing No. 4 sieve, shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter. However, in case the coarse aggregates are of quartizitic nature, then hydrated lime or a better material shall be allowed. At the time of use, it shall be sufficiently dry to flow freely. Filler material shall conform to following gradation:

Table 203-1: Gradation of Filler Material

US Standard Sieve	Percent Passing by Weight
No. 30	100
No. 50	95-100
No. 200	70-100

The coarse and fine aggregates shall meet the following applicable requirements:

a) The percentage of wear by the Los Angeles Abrasion test (AASHTO T 96) shall not be more than forty (40).

b) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T 104) shall be less than twelve (12) percent.

c) The Sand Equivalent (AASHTO T 176) determined after all processing except for addition of asphalt cement shall not be less than forty five (45).

d) Fine aggregates shall have a liquid limit not more than twenty five (25) and a Plasticity Index of not more than six (6) as determined by AASHTO T 89 and T-90.

e) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 2.5:1).

f) Stripping test shall be performed on coarse aggregates as described under AASHTO T-182 and only that material shall be allowed which qualifies the test.

g) The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behavior so that their affinity with the bitumen to be used is verified.

h) Petrographic examination of the coarse aggregate shall be conducted if so directed by the Engineer.

203.2.2 Asphaltic Material

Asphaltic Materials shall meet the relevant requirements of Item 301 of these Specifications. Asphalt binder to be mixed with the aggregate to produce asphaltic base shall be asphalt cement having penetration grade 40-50, 60-70 or 80-100 as specified by the Engineer. Generally it will meet the requirements of AASHTO M - 20.

203.2.3 Asphalt Concrete Base Course Mixture

The composition of the asphaltic concrete paving mixtures for base course shall conform to Class A and/or Class B shown in the following table:

TABLE 203-2

Combined Aggregate Grading Requirements

Mix Designation	**Class A**	**Class B**
Use	Leveling/Base	Leveling/Base
Compacted Thickness	70 - 90 mm	50 - 80 mm
U.S. Standard Sieve Size	**Percent passing by weight**	
2" (50 mm)	100	–
1.1/2" (38 mm)	90 - 100	100
1" (25 mm)	–	75 - 90
3/4" (19 mm)	56 - 75	65-80
1/2" (12.5 mm)	–	55 - 70
3/8" (9.5 mm)	–	45 - 60
No. 4 (4.75 mm)	23 - 40	30 - 45
No. 8 (2.38 mm)	15 - 30	15 - 35
No. 50 (0.300 mm)	4 - 10	5 - 15
No. 200 (0.075 mm)	3 - 6	2 - 7
Asphalt Content weight percent of total mix	3 (Minimum)	3 (minimum)

The asphalt concrete leveling / base course mixture shall meet the following Marshall Test Criteria.

Compaction, number of blows each end of specimen	75
Stability	1000 Kg (Min.)
Flow, 0.25 mm (0.01 in.).....	8-14
Percent air voids in mix	4-8
Percent voids in mineral aggregates.....	According to Table 5.3 MS-2 , Asphalt institute, sixth edition 1993.
Loss in Stability.....	25 percent (Max.)

Mixes composed of larger size aggregates with maximum size up to 38 mm (1.5 inches) will be prepared according to modified Marshall Method as per MS-2 Asphalt institute, sixth edition, 1993 or the latest edition. The procedure is basically the same as the original method except for following differences that are due to the larger specimen size that is used:

a) The hammer weighs 10.2 kg (22.5 lb.) and has a 149.4 mm (5.88 inches) flat tamping face. Only mechanically-operated device is used for the same 457 mm (18 inches) drop height.

b) The specimen has a 152.4 mm (6 inches) diameter by 95.2 mm (3.75 inches) height.

c) The batch weights are typically of 4 Kg.

d) The equipment for compacting and testing (molds and breaking heads) are proportionately larger to accommodate the larger specimens.

e) The mix is placed in the mold in two approximately equal increments, with spading performed after each increment to avoid honey-combing.

f) The number of blows needed for the larger specimen is 1.5 times (75 or 112 blows) of that required for the smaller specimen (50 or 75 blows) to obtain equivalent compaction.

g) The design criteria shall be modified as well, the minimum stability shall be 2.25 times and the range of flow values shall be 1.5 times normal-sized specimens.

h) Similar to the normal procedure, following values shall be used to convert the measured stability values to an equivalent value for a specimen with a 95.2 mm (3.75 inches) thickness, if the actual thickness varies:

Table 203-3: Conversion of the Measured Stability Values

Approximate Height mm	(inches)	Specimen Volume (Cubic cm)	Correlation Ratio
88.9	(3 1/2)	1608 to 1626	1.12
90.5	(3 9/16)	1637 to 1665	1.09
92.1	(3 5/8)	1666 to 1694	1.06
93.7	(3 11/16)	1695 to 1723	1.03
95.2	(3 3/4)	1724 to 1752	1.00
96.8	(3 13/16)	1753 to 1781	0.97
98.4	(3 7/8)	1782 to 1810	0.95
100.0	(3 15/16)	1811 to 1839	0.92
101.6	(4)	1840 to 1968	0.90

203.2.4 Job-Mix Formula

At least one (1) week prior to production, a Job-Mix Formula (JMF) for the asphaltic base course to be used for the project, shall be established jointly by the Engineer and the Contractor in the project laboratory. Job mix formula shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

The JMF shall be established by MARSHALL Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993, or the latest Edition.

The JMF, with the allowable tolerances shall be within the range specified in Item 203.2.3. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

The ratio of wt. of filler (passing sieve No. 200) to that of asphalt shall range between 1–1.5 for hot climate areas with maximum ambient temperature more than 40°C.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto. Moreover upon receiving the job-mix, approved by the Engineer, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that, when compared to job mix formula shall be within the following limits, however, due to this variation in percentage of materials no individual sieve component shall fall outside the envelope given in Table 203-1 for applicable class of combined gradation.

Maximum Allowable Variation of Percentage of Materials

Retained No. 4 and larger	± 7.0%
Passing No. 4 to No. 100 sieve	± 4.0%
Passing No. 200	± 1.0%

Asphalt Content

Weight percent of total mix	± 0.3%

In addition to meeting the requirements specified in the proceeding items, the mixture as established by the JMF shall also satisfy the following physical property

Loss of Marshall Stability by immersion of specimen in water at sixty (60) degree centigrade for 24 hours as compared with stability measured after immersion in water at 60 degrees centigrade for 20 minutes shall not exceeds twenty five (25) percent. If the mixture fails to meet this criterion, JMF shall be modified or an anti-stripping agent shall be used.

Should a change of sources of materials be made, a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new Job Mix Formula will be required.

203.3 CONSTRUCTION REQUIREMENTS

203.3.1 Bituminous Mixing Plant

Plants used for the preparation of bituminous mixtures shall be "Batching Plants" conforming to AASHTO M 156, and of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. Plant shall have minimum three cold bins and at least 3.5 decks of hot sieves.

203.3.2 Preparation of Aggregates

Before being fed to the dryer, aggregates for the asphaltic base courses shall be separated into three or more sizes and stored separately in cold bins. One bin shall contain aggregate of such size that eighty (80) percent will pass sieve No. 4, and the other two bins shall contain aggregate of such sizes that eighty (80) percent will be retained on sieve No. 4. Should fine material, be incorporated in the mix, separate bin shall be provided in addition to the three bins mentioned above. If filler is used as a separate component it will also be stored and measured separately and accurately before being fed into the mixer through filler screw mechanism.

Asphalt cement shall be heated within a temperature range of hundred and thirty five to hundred and sixty three (135-163) degrees centigrade at the time of mixing. Asphalt cement heated above maximum shown shall be considered overheated and shall be rejected and removed from job site.

Dried aggregate weighed and drawn to pugmill shall be combined with proportionate quantity of asphalt cement according to the job mix formula. Temperature of asphalt, except for temporary fluctuations, shall not be lower than fifteen (15) degrees centigrade below the temperature of the aggregate, at the time; the two materials enter into the pugmill.

For placing the materials in bins or in moving them from bins to the dryer, any method which causes segregation or uncontrolled combination of materials of different grading shall be discontinued and the segregated or degraded materials shall be prescreened for reuse.

Each aggregate ingredient shall be heated and dried at temperature not to exceed hundred and sixty three (163) degrees centigrade. If aggregate contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of hundred and sixty three (163) degrees centigrade, they shall be removed from the bins and returned to their respective stock piles. In no case, shall the temperature of asphaltic mix exceed 163 degree centigrade when discharged from the pugmill.

Immediately after heating, the aggregates shall be screened to required sizes and stored in separate hot bins for batching and mixing with bituminous material.

Asphalt plant shall have minimum three and half (3 $^1/_2$) sieve decks to effectively control the gradation of hot bins.

203.3.3 Hauling Equipment

Dump truck used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with an approved material to prevent adhering of material to the beds. Each truck shall have a cover of canvas or of other suitable material of sufficient size as to protect the mixture from the weather. The mixture will be delivered on the road at a temperature not less than hundred and thirty (130) degree C. Drivers of dump trucks will ensure that while reversing the vehicles, paver is not pushed back producing a hump.

203.3.4 Bituminous Pavers

Bituminous pavers shall be self-contained, power-propelled units, provided with an automatically controlled activated screed or strike-off assembly, heated if necessary, capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the plans. Pavers used for shoulders and similar construction shall be capable of spreading and finishing course of bituminous plant mix material in widths shown on the plans.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

The screed or strike-off assembly shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture. When laying the mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The paver shall be operated at speeds which will give the best result for the type of power being used.

The mixed material shall be delivered to paver in time to permit completion of spreading, finishing and compaction of mixture during day light hours.

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope. The sensor shall be so constructed that it will operate from a reference line or a ski-like arrangement.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation.

Manual operation will only be permitted in the construction of irregularly shaped and minor areas.

Whenever a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods in order to allow the contractor to use the asphalt already produced at the plant or in transit, provided this method of operation will produce results otherwise meeting the specifications.

Reference lines will be required for both outer edges of the traveled way for each main line roadway for vertical control. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference lines or by means of a ski and a slope control device or a dual ski arrangement. When the finish of the grade prepared for paving is superior to the established tolerance and, when in the opinion of the Engineer, further improvement to the line, grade, cross sections and smoothness can best be achieved without the use of the reference line, a ski-like arrangement may be substituted subject to the approval of the Engineer. The use of the reference lines shall be reinstated immediately whenever the Contractor fails to maintain a superior pavement. The Contractor shall furnish and install all pins, brackets, tensioning devices, wire and accessories necessary for satisfactory operation of the automatic control equipment.

203.3.5 Rollers

Rollers shall be steel wheel, pneumatic tyre and vibratory, or a combination thereof. The roller(s) shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Vibratory rollers shall be acceptable for bituminous mixture compaction. The use of equipment, which results in excessive crushing of the aggregate, will not be permitted.

203.3.6 Preparation of Base or Existing Pavement Surface

Before spreading materials, the surface of base or existing pavement on which the mix is to be placed shall be conditioned by application of a prime or tack coat as specified.

After a prime coat is applied, it shall be left undisturbed not less than twenty four (24) hours. The Contractor shall maintain the primed surface until the mix material has been placed. This maintenance shall include the spreading of sand or other approved material, if necessary to prevent adherence of the prime coat to the tyres of vehicles using the primed surface, and patching any breaks in the primed surface with additional bituminous material. Any area of primed surface that has become damaged shall be repaired before the mix is placed, to the satisfaction of Engineer. It shall be ensured that primed surface is not in tacky condition, when premix is laid.

After a tack coat is applied, it shall be allowed to dry until it is in the proper condition of tackiness to receive the mix. The tack coat shall be applied only as far in advance of the placing of mix, as is necessary to obtain the proper condition of tackiness. Any breaks in the tack coat shall be repaired.

When the surface of the existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by leveling course as directed. The leveling course mixture shall conform to the requirements of Item 203.2.

A thin coating of bituminous material shall be sprayed on contact surface of curbing, gutters, manholes, and other structures, prior to the bituminous mixture being placed against them.

203.3.7 Spreading and Finishing

The mixture shall be laid upon an approved surface, spread and struck off to the section and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

The longitudinal joint in one layer shall offset to that in the layer immediately below, by approximately 15.0 cm; however, the joint in the top layer shall be at the centerline of the pavement if the roadway comprises two lanes of width, or at lane lines if the roadway is more than 2 lanes in width.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand tools. For such areas the mixture shall be dumped, spread and screeded to give the required compacted thickness, ensuring even distribution of coarse and fine material.

When production of the mixture can be maintained and wherever practical, pavers shall be used in echelon to place the wearing course in adjacent lanes and compacted to form a surface without lateral joint.

All mixtures shall be spread at a temperature of not less than hundred and thirty (130) degree C and all initial rolling or tamping shall be performed when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between 165 degree C and 190 degree C, subject to “Weather Limitations” mentioned under 203.3.13. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

203.3.8 Compaction

After spreading and strike off and as soon as the mix condition permits the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling shall not be prolonged when cracks appear on the surface.

Initial or breakdown rolling shall be done by means of either a tandem steel roller or three wheeled steel roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement.

The number and weight of rollers shall be sufficient to obtain the required compaction while the mixture is still in workable condition. The sequence of rolling and the selection of roller types shall provide the specified pavement density. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible.

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centerline, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centerline. Intermediate rolling with a pneumatic tyred roller shall be done behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In no case shall the temperature be less than hundred and twenty (120) degree C. for initial break down rolling while all other compaction operations shall be completed before the temperature drops down to hundred and ten (110) degree C.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and a minimum density of Ninety seven (97) percent of a laboratory compacted specimen made from asphaltic material obtained for daily Marshall density is achieved.

Any displacement resulting while reversing the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, wheels of rollers shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, tempers be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective in finish or density shall be removed and replaced with fresh hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of bituminous material shall be removed and replaced.

Sequence of laying and compaction of premix shall be so managed, that a long time does not elapse between successive dump trucks, which may cool down the uncompacted premix, between paver and compacted asphalt below 120^{o} C

203.3.9 <u>Frequency of Testing for Cores</u>

One core shall be taken for each 100 linear meter of each lane of Asphaltic Base, or fraction thereof, in special cases. If the core so taken is failed against the specified 97% density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) meters on either side with respect to the failing core and shall be tested against field density. If all the three cores give an average of 97% compaction, and the individual compaction of the core is not less than ninety five (95) percent, then the compaction is acceptable. If average of the cores further fails against compaction, then retake the cores at a distance of fifteen (15) meters on either side and compaction shall be checked for all the five cores in the same fashion. If average of five

cores is 97%, the area will be accepted. In case average is ninety six 96% or more, then Engineer may withhold the payment in full or partly and observe behaviour during maintenance period, for the release of payment or otherwise. In case of failure of the average of these five cores giving average compaction of less than 96%, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner at the expense of contractor.

203.3.10 Surface Tolerances

After completion of final rolling, the finished surface shall be tested for smoothness with three (3) meters straightedge by Engineer at selected locations. The variation of surface from testing edge of straight edge between any two (2) contacts with the surface shall at no point exceed six (6) millimeters when placed either parallel or perpendicular to centreline of roadway.

Any irregularities that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area and replacing with new asphaltic base course without additional cost to the Employer.

203.3.11 Base Thickness Tolerances

For determination of thickness, one (1) core for each hundred (100) linear meter of each lane shall be taken. Unless otherwise permitted, cores extracted for thickness measurement shall not be used for density determination and density cores shall not be used for thickness measurements.

When layer thickness of asphaltic base course is deficient by more than five (5) mm from that specified in the Drawings, the deficiency shall be removed with satisfactory base course material and/or made up by additional asphalt concrete wearing course thickness without extra cost to the Employer. If such remedial action is authorised, revised thickness determinations shall be made by measurements of new cores taken after placing of "Asphaltic Wearing Course" material or as directed by the Engineer. If base course deficiencies are corrected in this manner, full payment for the "Asphaltic Base Course" will be made to the Contractor, but no additional payment will be made for the increase in thickness of the "Asphaltic Wearing Course".

203.3.12 Acceptance Sampling and Testing

Acceptance of samples and testing of materials and construction requirements, shall be governed by the relevant, "Table for Sampling and Testing Frequency" or as approved by the Engineer.

203.3.13 Weather Limitations

Hot asphaltic mixtures shall be placed only when the rising air temperature is four (4) degrees centigrade or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

203.3.14 Trial Section

Contractor shall prepare a trial section before the start of work in light of procedure given in clause 1.20 (General).

203.4 MEASUREMENT AND PAYMENT

203.4.1 Measurement

The quantities for asphaltic leveling / base course will be measured by volume in cubic meters compacted in place. Measurement shall be based on the dimension as shown on plan or as otherwise directed or authorized by the Engineer. No measurement shall be made for unauthorized areas or for extra thickness.

The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of liquid asphalt, wasted or remaining on hand after completion of the work, shall not be measured or paid for.

203.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item. Asphalt additive or anti stripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items of Asphaltic Base Course.

Pay Item No.	Description	Unit of Measurement
203 a	Asphaltic base course plant mix (class A) with layer thickness between 70-90 mm	CM
203 b	Asphaltic base course plant mix (class B) with layer thickness between 50-80 mm	CM
203 c	Asphaltic levelling course plant mix (class A) with layer thickness between 70-90 mm	CM
203 d	Asphaltic levelling course plant mix (class B) with layer thickness between 50-80 mm	CM

SECTION 204 SOIL CEMENT STABILIZED SUBBASE AND BASE

204.1 DESCRIPTION

The work shall consist of performing all operations in connection with the construction of cement stabilized sub base or base and all incidentals in accordance with the specifications in conformity with the lines, grade, thickness and typical cross-sections shown on the plans or as directed by the Engineer.

204.2 MATERIAL REQUIREMENTS

204.2.1 Mineral Aggregate

Aggregate shall be clean, tough, hard durable particles free of decomposed stone, organic matter and other deleterious substances and shall consist of material of which at least 50% by weight of the total aggregates shall have at least two (2) mechanically fractured faces for cement stabilized sub base whereas for cement stabilized base course, material shall have at least Ninety (90) percent by weight of total aggregate having two (2) mechanically fractured faces.

Coarse aggregate retained on sieve No. 4 shall have a percentage of wear by Los Angeles Abrasion as determined by AASHTO T 96 not more than forty five (45) for base course and fifty (50) for sub base material.

Fraction passing 0.075 mm (No. 200) shall not be greater than two-third of the fraction passing the 0.425 mm (No. 40) sieve. The fraction passing 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 25% and plasticity index not greater than 6.

Sandy and gravely soils used for cement stabilization shall fulfill the following grading requirements.

Passing maximum size 50 mm sieve	100%
Passing AASHTO No. 4 sieve	above 50%
Passing AASHTO No. 40 sieve	above 15%
Passing AASHTO No. 200 sieve	below 5%
Clay fraction, finer than 0.002 mm	below 3%

204.2.2 Cement

Cement shall conform in all respect to requirement specified under sub-item 111.2.2 and item 401 "Concrete".

204.2.3 Water

Water used for cement stabilized base course or sub base shall conform in all respect to requirements specified under sub-item 112.2.3.

204.2.4 Mix Design Requirements in Laboratory

Prior to commencement the work of stabilization, proposed mix design indicating the exact percentage of cement and water to be used so as to obtain a uniform mixture, shall be submitted by the Contractor for Engineer's approval, and shall fulfill the following requirements:

i) The mixture sample submerged in water for two hours before crushing, after storage in a box having minimum humidity of ninety five (95) percent for Twenty four (24) hours shall have a minimum compressive strength of twenty three (23) kg/sq.cm for sub base and thirty (30) kg/sq. cm for base respectively.

ii) The maximum permissive swelling of volume shall be two (2) percent and maximum loss in weight eight (8) percent when tested in accordance with AASHTO T-135.

iii) Maximum variation during constructions shall be as given below:-

a.	Cement Content:	-1 to +1% of that given in the mix design.
b.	Water contents:	0 to +2% of that given in the mix design.

iv) Bituminous material for curing seal shall be any one of the following:

Type	Applicable Specifications
RC-250	AASHTO M-81
MC-250	AASHTO M-82
SS-1	AASHTO M-140
RT-5	AASHTO M-52

Optimum moisture content shall be determined in accordance with AASHTO T-134 by placing moist sample under shade for seven days and crushing after two hours of immersion in water.

204.2.5 Composition of Mixture at Site

The granular material shall thoroughly be mixed at site with sufficient cement to obtain required crushing strength. The cement content shall be determined at the laboratory so that minimum compressive strength of mixture is fifty (50) kg/sq. cm for sub base and eighty (80) kg/sq. cm for base respectively at seven (7) days. The moisture content of the mix cement stabilized material shall not be less than the optimum as determined by AASHTO T-134 Method and nor more than two (2) percent above the optimum as determined by this test or such higher value as may be agreed by the Engineer on basis of preliminary trial.

204.3 CONSTRUCTION REQUIREMENTS

204.3.1 Stationary Plant Method

Equipment, tools, machines used in the performance of cement stabilized sub base, base shall be subject to the approval of Engineer and shall be maintained in satisfactory working condition at all times.

If stationary plant is used, it shall be of the power driven paddle or pan type and may be of batch or continuous type.

If batch mixer is used, measured amount of material and cement shall first be placed in mixer, water being added to bring moisture content of mixture within the optimum range. Mixing shall be continued until mixture is uniformly mixed but in no case less than one minute mixing time.

The mixing plant shall be of approved type, coordinated and operated as to produce mixture within mix design requirements and shall be of sufficient capacity.

The aggregate, cement and water shall be mixed at an approved central mixing plant by either continuous-flow or batch type mixer revolving blades or rotary drum mixer.

The plant shall be equipped with feeding and metering devices that add the materials; cement and water into the mixer in specified quantities; mixed thoroughly and sufficiently to obtain intimate and uniform mixture with out cement lumps.

The mixture shall be transported to paving area in trucks or other approved equipments having clean bed within a maximum hauling time of forty five (45) minutes.

The mixture shall be placed on moist sub grade/or sub base without segregation at a rate that will produce a uniformly compacted layer conforming to the required grade and cross-section. The mixture shall be spread by spreader within thirty minutes after placement of mixture.

Compaction shall start as soon as possible after spreading and elapsed time between the addition of water to mixture and start of compaction shall not exceed ninety (90) minutes.

204.3.2 Mix in Place Method

Cement stabilized sub base/base course can also be constructed by MIX-IN-PLACE method. The plant used for pulverizing and mixing the stabilized material shall be approved by the Engineer on the basis of trial conducted to establish that the plant is capable of producing the degree of mixing and uniformity of material according to specification requirement. The material shall be processed throughout the depth of layer with blades of approved mixing equipment. The cement shall be spread ahead of mixer by means of cement spreader, fitted with a device to ensure uniform and required rate of spread of cement both transversely and longitudinally.

Moisture content of the material shall be adjusted to optimum using water sprayer of such design that water is discharged in uniform and controllable manner both transversely and longitudinally.

204.3.3 Construction Joints

In the end of each day construction, a straight transverse construction joint shall be formed by cutting into completed work to form a true vertical face.

For large area, a series of parallel lanes of convenient length and width meeting approval of Engineer shall be built with true vertical face free of loose or shattered material.

Guide stakes shall be set for cement spreading and mixing.

Grade and alignment stakes shall be furnished, set and maintained by contractor, in order that the work shall conform to the lines, grade and cross-sections shown on the drawing.

All material shall be placed and spread evenly by mechanical spreader capable of leveling off the material to an even depth. The mixture shall be mixed uniformly with proper moisture content. Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirements, additional approved material shall be spread in such amounts as are found to be necessary and the added material shall be uniformly mixed into previously placed material, adding water as required to obtain the specified density.

204.3.4 Compaction

The thickness of layer shall be as shown on the Drawings but in no case shall be less than eight (8) centimeters. If thickness of each layer does not exceed twenty centimeters, it shall be constructed as one layer. If thickness of layer exceeds twenty (20) centimeters, it shall be constructed in two or more layers each within the range of eight (8) to twenty (20) centimeters in compacted thickness.

The mixture shall be spread and finished true to crown and grade by machine or hand method where machine methods are impracticable as determined by the Engineer and shall be thoroughly compacted with approved rollers until entire depth and width of sub base/base is uniformly compacted to maximum density of 95% as tested according to procedure outlined in AASHTO T-134.

The compaction shall be complete as soon as possible after mixing, normally within three (3) hours after adding water depending on setting time of cement and the weather conditions.

Compaction shall not take place after cement hydration and any material that has been mixed or deposited after cement has hydrated shall be removed and replaced with fresh mix material.

204.3.5 Preliminary Trial

At least one (1) week before main work of stabilization is started contractor shall construct a trial section of two hundred (200) meters in length at location approved by the Engineer with same material, equipment, mix proportion and construction procedure that he proposes to use for the main work.

Purpose of this trial section is to determine efficiency of mixing, spreading, compaction, suitability of construction procedures and depth of layer being compacted with available compactive effort.

In place density determination will be made using AASHTO T-191 or AASHTO T-205 & T-238 Method.

204.3.6 Curing/Maintenance

After compaction the stabilized sub base/base layer shall be protected against drying out by keeping it continuously damp for a period of at least three (3) days or by coating with approved curing material at the rate approved by the Engineer.

The completed cement stabilized sub base/base shall be maintained in an acceptable condition at all the times, prior to construction of subsequent asphaltic layer.

No vehicular traffic shall be allowed to pass on the compacted layer until curing period has elapsed with a minimum no-traffic period of seven (7) days.

Cement stabilized sub base/base shall be constructed only when the atmospheric temperature is above 4 degrees centigrade and when the weather is not rainy.

204.3.7 Tolerance

The surface of each sub base/base course shall be properly shaped to a smooth uniform surface parallel to the finished surface of the carriageway and shall not vary more than the limits as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

The completed Sub base/Base course shall be tested for required thickness and surface before acceptance. Any area having compacted thickness less than the thickness shown in the bill of quantities and/or on the drawings shall be rectified by scarifying the top seventy five (75) mm, reshaping with added material and recompacting all to specification. Skin patching of an area without scarifying the surface to permit proper bonding of added material will not be permitted.

204.4 MEASUREMENT AND PAYMENT

204.4.1 Measurement

The unit of measurement for payment shall be cubic meter of the compacted and accepted sub base/base material as measured in place. Measurement shall not include any areas in excess of that shown on the drawings except the areas authorized, in writing, by the Engineer.

Measurement of cement content used shall be the number of metric Ton consumed to stabilize sub base/base. This quantity of cement used shall not exceed the theoretical percentage established in the laboratory.

Bituminous curing material shall be measured by the metric Ton. The contractor shall furnish in duplicate certified weight tickets from the batch scales of commercial plants.

204.4.2 Payment

Measured quantity of stabilized sub base/base determined as provided above shall be paid for at the contract unit price per cubic meter for a particular item listed below and shown on the Bill of Quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment, handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsuitable area and unsatisfactory material; maintenance including protection of stabilized sub base/base layer and incidentals necessary for completion of work except cement consumed which shall be paid separately as measured above. Payment for bituminous curing material shall include all labour, material, heating (if required) equipment, spreading and protection from traffic as directed by the Engineer.

Pay Item No.	Description	Unit of Measurement
204 a	Cement stabilized base	CM
204 b	Liquid asphalt for curing seal, type Mc-250	TON
204 c	Emulsified asphalt for curing seal, type Sc-1	TON

SECTION 205 CRACK - RELIEF LAYER

205.1 DESCRIPTION

The work shall consist of constructing a layer of graded crushed aggregate or asphaltic open-graded plant mix on a prepared soil-cement base course in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the Drawings.

205.2 MATERIAL REQUIREMENTS

205.2.1 Aggregates

Material for graded crushed aggregates shall in all respects conform with the requirements specified under Item 202, with the following exceptions and supplementary requirements:

a) The portion of the aggregate retained on the 9.5 mm. (3/8 inch) sieve shall not contain more than 10 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimension = 2.5:1).

b) Crushed aggregates shall consist of particles with not less than Ninety (90) percent of the portion retained on the 4.75 mm. (No. 4) sieve having at least two fractured faces.

Aggregates for the asphaltic open-graded plant mix shall conform to the requirements of Item 203.2.1 with the following exceptions:

a) Fine aggregates and mineral filler will be required.

b) Sand equivalent and plasticity requirements are not applicable.

205.2.2 Asphaltic Material

Asphaltic binder shall be asphalt cement, 60-70 penetration grade, meeting the requirements of AASHTO M-20.

205.2.3 Asphaltic Open-Graded Mixture

The composition of the asphaltic open-graded crack-relief layer shall meet the following criteria:

Table 205-1: Aggregate Grading Requirements

Sieve Designation mm	Sieve Designation Inch	Percent Passing by weight
50	2	100
37.5	1.1/2	75-90
19	3/4	50-70
4.75	No. 4	8-20
0.15	No. 100	0-5
Asphalt Cement Content of total Mix		2-3% by weight
Mixing Time		30 seconds (Maximum)
Mix Design		Within Master Range Gradation

The exact percentage of asphalt cement content shall be such that at least Ninety five (95) percent coating of aggregates will be achieved when tested in accordance with AASHTO T-195.

205.3 CONSTRUCTION REQUIREMENTS

Prior to construction of the crack-relief layer (CRL) the completed soil-cement base course shall be duly accepted by the Engineer.

205.3.1 Graded Crushed Aggregate

Construction of this layer shall conform in all respects to the requirements specified under Item 202.3.

205.3.2 Asphaltic Open-Graded CRL

Construction of this layer shall conform in all respects to the requirements specified under Item 203.3, except as provided below:-

a) Compaction shall be accomplished by ten (10) Ton steel Wheeled tandem rollers. A maximum of three complete coverages, or as otherwise directed by the Engineer, shall be sufficient. No density test will be required, however the compaction shall be achieved in the same manner as displayed in the total test and to satisfaction of the Engineer.

b) The consistency and temperature of the mix shall be so controlled that it does not squeeze out or move under the pressure of compacting roller. For this purpose, trial reaches shall be prepared by the contractor to fix the above parameters.

In order to ensure the stability of CRL before the placement of any subsequent layer or opening of a layer to traffic, a priming time of 4 days in hot weather will be allowed. This time may be reduced to two days where the lower temperature allows.

c) All traffic shall be kept off this layer until a subsequent layer has been placed on it. Any damage caused by traffic moving directly on the crack-relief layer shall be the responsibility of the Contractor and all necessary repair work thereto shall be at the Contractor's expense.

205.4 MEASUREMENT AND PAYMENT

205.4.1 Measurement

The quantity of graded crushed aggregate crack-relief asphaltic open graded layer to be paid for shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed graded crushed aggregate crack-relief layer.

The quantity of asphaltic open graded crack relief layer shall be measured in cubic meters by taking out cores as detailed for Base Course Asphalt under item 203.4.1

The quantity of Asphaltic material is included in the mixture and will not be measured separately.

205.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all costs necessary for the proper completion of the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
205 a	Filling of joints and cracks with asphaltic open graded plant mix Crack-Relief layer.	CM
205 b	Filling of joints and cracks with graded crushed aggregate Crack-Relief layer.	CM

SECTION 206 WATER BOUND MACADAM BASE

206.1 DESCRIPTION

This work shall consist of furnishing and placing one or more courses of clean crushed stone base mechanically interlocked by rolling, and voids thereof filled with screening and binding material with the assistance of water, laid on a prepared subgrade, sub base, or existing pavement in conformity with the lines, grades and cross-sections shown on the drawings.

Unless otherwise directed by the Engineer this item of work may be applied to road structure or shoulders.

206.2 MATERIAL REQUIREMENTS

Coarse aggregates either crushed or broken stone shall conform to the quality requirements as specified hereunder, except that no CBR testing will be required. The gradation curve of the coarse aggregate shall be within the envelop limits given below:

Table 206-1: Envelop Limits for Coarse Aggregate Gradation Curve

Sieve Designation		Percent Passing by weight		
mm	Inch	Class A	Class B	Class C
102	(4")	100		
89	(3.1/2:)	90 - 100		
76	(3")	–	100	
63.5	(2.1/2")	25 - 60	90 - 100	100
50	(2")	–	25 - 75	90 - 100
37.5	(1.1/2")	0 - 15	0 - 15	35 - 70
25	(1")	–	–	0 - 15
19	(3/4")	0 - 5	0 - 5	0 - 5
12.5	(1/2")	–	–	–

Fine aggregate (filler material or screenings) shall consist of crushed stone screenings or any other fine material approved by the Engineer. It shall be free from clay lumps, dirt and other objectionable material. The fine aggregate shall be of the following gradation.

Sieve Designation		Percent Passing by weight
mm	Inch	
9.5	3/8	100
4.75	No. 4	85-100
0.15	No. 100	10-30

The material passing No. 40 sieve shall have a liquid Limit of not more than twenty five (25) percent and a Plasticity Index of not more than six (6).

206.2.1 Physical Requirements

The additional physical requirements of coarse aggregates for water bound macadam will satisfy the following limits:-

a. Loss Angeles Abrasion Value Max 45%
b. Flakiness Index Max 15%
c. The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T-104) shall be less than twelve (12).

206.2.2 Binding Material

Binding material to prevent raveling of water bound macadam shall consist of a fine grained material passing 100 percent through 425 micron sieve and possessing P.I value of four to nine (4-9) when the Water Bound Macadam (WBM) is to be used as a surfacing course, and up to 6 when WBM is being adopted as sub-base/base course with bituminous surfacing. If lime stone formations are available nearby, lime stones dust or as directed by the Engineer, may be used fully employed for this purpose.

206.3 CONSTRUCTION REQUIREMENTS

206.3.1 Equipment

Any combination of machines or equipment that will produce the results meeting these specifications may be used with the approval of the Engineer. These include mechanical spreaders, water sprinklers and rollers/compactors.

206.3.2 Structure Preparation

Preparation of surface for water bound macadam, shall be carried out in the same manner as for aggregate base course item 202.3.1.

Where the existing road surface is black topped, 50 mm x 50 mm furrows shall be cut in the existing surface at one (1) meter intervals at forty five (45) degree to the centre line of the carriage-way before proceeding with the laying of coarse aggregates.

Before starting with WBM Construction, necessary arrangements shall be made for the lateral confinement of aggregates. One method is to construct side shoulders in advance to a thickness corresponding to the compacted layer of the WBM course. After shoulders are ready, there inside edges may be trimmed vertical and the included area cleaned of all spilled material thereby setting the stage for spread of coarse aggregates. The practice of constructing WBM in a trench section excavated in the finished formation must be avoided.

206.3.3 Spreading and Compaction

Crushed stone shall be deposited and spread on the prepared surface to the proper depth so that the compacted layer will not exceed two and a half (2.1/2) times the thickness of maximum aggregate size. Each layer shall be inspected thoroughly before rolling to detect high or low spots. Crushed stones shall be added or shifted to provide a true surface. The course aggregate layer, after being laid to proper thickness, shall be lightly rolled sufficient only to establish the required grade and level of the stones.

Spreading of the coarse aggregates shall be followed by rolling with a smooth wheel roller weighing at least 10 tons. Rolling shall begin at the lower edge of the shoulders to lock the stones firmly at the edge, then progress gradually towards the centre line. Rolling shall continue until the aggregate is well keyed and does not creep ahead of the roller.
In no case, shall coarse aggregates be stored in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed base be permitted, however dumpers shall be allowed at the construction area where the material will be spreaded quickly after dumping.

Following the initial rolling, dry screenings shall be applied uniformly over the surface. Dry rolling shall be continued while screenings are being applied. The surface shall be swept with mechanical or hand brooms to aid spreading of the screenings.

When the interstices in the coarse aggregate are filled with screenings, the surface shall be sprinkled with water until it is saturated. The rolling, sprinkling and application of additional screenings shall continue until a grout is formed that fills all the voids and forms a wave of grout in front of the roller.

When more than one layer is required to complete the Macadam base course to the thickness shown on the drawings, each layer shall be constructed as before prescribed.

206.3.4 Construction Control Testing

Tests for compliance with the requirements of Item 206.2 will be made as often as deemed necessary and to the satisfaction of the Engineer.

206.3.5 Maintenance

The completed base course shall be maintained in an acceptable condition until the necessary subsequent treatment is applied.

206.4 MEASUREMENT AND PAYMENT

206.4.1 Measurement

The quantity of Water Bound Macadam Base to be paid for shall be measured by the theoretical volume in place in cubic meters, as shown on the Drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed Water bound Macadam Base Course. No allowance will be given for materials placed outside the theoretical limits shown on the cross-sections.

206.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter of Water Bound Macadam Base, for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
206 a	Water Bound Macadam base with course aggregate class B including screening material (stone dust) to fill all voids and compaction as explained under the item, of the depth specified on the drawing.	CM

SECTION 207 DEEP PATCHING

207.1 DESCRIPTION

This work shall be carried out in patches of roads where the existing road base material has moved and is lying in loose condition. Requirement under this item is to remove the existing road base and to strengthen it to take new layer of aggregate or water bound macadam base.

207.2 MATERIAL REQUIREMENTS

Fresh aggregate base or water bound macadam base may be required to be added to existing road base. Specification for such material shall conform to material requirements of item 202.2 or 206.2.

207.3 CONSTRUCTION REQUIREMENTS

Patches of roads in which surface courses have broken and road base has moved, the material which has lost its compaction shall be removed. Next layer shall be watered and compacted, thereby the removed material shall be placed back duly screened to remove plastic contamination, by hand picking and passing though sieve No. 4. after properly watering and mixing. Material will be recompacted in layers not exceeding fifteen (15) cms thick with approved equipments. Additional material will be added, if needed particularly non-plastic fines passing sieve No. 4.

207.4 MEASUREMENT AND PAYMENT

207.4.1 Measurement

The quantity of deep patching to be paid for shall be measured in square meter of the area demarcated or approved by the Engineer. The minimum area will be taken as 0.5 square meters irrespective of the size of the pot hole.

207.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per square meter of deep patching, which price payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
207 a	Deep patching (0-15cm)	SM
207 b	Deep patching (15-30cm)	SM

SECTION 208 REINSTATEMENT OF ROAD SURFACE

208.1 DESCRIPTION

This work shall consist of reinstatement of worn out road surface with a material approved by the Engineer. Pot holes, ditches and depressions shall be filled with the approved materials in layers in conformity with lines, grades, sections and dimensions, as directed by the Engineer.

208.2 MATERIAL REQUIREMENTS

The material used under this item shall conform to the material requirement of different B.O.Q. items selected for use by the Engineer.

208.3 CONSTRUCTION REQUIREMENTS

The contractor shall remove loose material from the pot holes or from road depressions and shall also reshape the holes and depression by removing firm material as directed by the Engineer and dispose all material according to the instruction of the Engineer. The surface thus exposed shall be compacted in accordance with applicable requirement, for reinstatement of surface the Engineer shall select item of work as mentioned here under or any other item of work as per site requirement:

1) Granular sub base.
2) Aggregate base course.
3) Water bound macadam.
4) Asphalt base course.
5) Surface treatment.

The Engineer may select one, or more than one of the items mentioned above to reinstate the pot hole or depressions in the road surface according to size and depth of the hole or depression.

208.4 MEASUREMENT AND PAYMENT

208.4.1 Measurement

The quantities to be paid for shall be the number of square meter of pot holes or road depressions, reinstated in accordance with the requirement of this item.
The material used for reinstatement of the pot hole or road depression shall be measured in cubic meter or tones as applicable under the item used.

208.4.2 Payment

The accepted quantities measured, as provided above shall be paid for at the contract unit price per square meter of reinstated surface, as for the pay item listed below and as shown on the bill of quantities which price shall constitute full compensation for excavation and disposal of material, watering, rolling, labour, equipment, tools, and incidental necessary to complete this item.
However the material used such as sub base, aggregate base course, water bound Macadam or asphaltic base course shall be paid at the rates applicable to the item.

Pay Item No.	Description	Unit of Measurement
208 a	Reinstatement of road surface (Pot holes, ditches and depressions to be filled with approved materials) material paid separately.	SM

SECTION 209 SCARIFICATION OF EXISTING ROAD/BREAKING OF ROAD PAVEMENT STRUCTURE

209.1 DESCRIPTION

This item shall consist of scarification of existing road surface or breaking of existing road pavement structure to ensure bondage of new layer with the existing road pavement and to ensure drainage of water below the surface of freshly laid aggregate base. The surface on which the base material is to be constructed shall be approved and accepted by the Engineer prior to placing the crushed stone base aggregate.

209.2 CONSTRUCTION REQUIREMENTS

The method of scarification of road surface or breaking of pavement structure shall be proposed by the contractor and approved by the Engineer, in accordance with the requirements under site conditions.

After the existing pavement structure has been broken off, the material shall be removed and disposed off outside the right of way, according to the satisfaction of the Engineer. The surface obtained after scarification or breaking the existing pavement shall be compacted to the density prescribed under item 108.3.1. Payment of such compaction shall be included in the contract price for item 209.

209.3 MEASUREMENT AND PAYMENT

209.3.1 Measurement

The quantity for road pavement structure broken and removed, to be paid for shall be measurement in Cu. meter to a depth as shown in the drawings/cross sections or as specified by the Engineer and in the area earmarked by the Engineer for such purpose.

The quantity for road pavement structure scarified, to be paid for shall be measured in Sq. meter as shown in the drawings/cross sections or as specified by the Engineer and in the area earmarked by the Engineer for such purpose.

209.3.2 Payment

The quantities as measured above shall be paid for at the contract unit price per Cu. meter of breaking of road pavement structure and per Sq. meter of scarification of existing road pavement structure, for carrying out the works mentioned above including cost of labour, equipment, tools and incidental necessary to complete these items.

Pay Item No.	Description	Unit of Measurement
209 a	Breaking of existing road pavement structure	CM
209 b	Scarification of existing road pavement	SM

SECTION 210 PAVEMENT WIDENING

210.1 DESCRIPTION

This work shall consist of the widening of the existing pavement and finishing of the completed work in accordance with the specifications and in conformity with the lines, grades, thickness of each pavement component and typical cross-sections shown on the plans or as directed by the Engineer.

210.2 MATERIALS

Materials for the construction of "Pavement Widening" shall conform to the requirements specified in relevant items of Sub base and Base course in these specifications.

210.3 TRENCHING

The contractor shall excavate along the edge of the existing pavement for the full depth and width as indicated on the Drawings or as directed by the Engineer. The bottom of the trench shall be compacted with rollers and/or tampers approved by the Engineer to minimum ninety five (95) % of the maximum dry density as per AASHTO T-191 method. If the plans do not call for a specific type of compaction, the sub grade, sub base or base shall be compacted by rolling with an approved type trench roller until the entire surface is smooth, firm and at the designated elevation. Adequate provisions shall be made for drainage of the trench to prevent damage to the subgrade. Prior to placing any widening material, the trench shall be cleaned of all loose material. The edge of the existing pavement shall be thoroughly cleaned. The trench must be approved by the Engineer, before placing any widening material. All subsequent layers shall be compacted to the degree as shown under relevant item of these specifications.

210.4 SPECIAL PROVISIONS FOR HANDLING TRAFFIC

Widening operations shall be permitted on only one (1) side of the pavement at a time and excavation of trenches shall be permitted only sufficiently in advance of other operations to ensure a continuity of the operations of excavating, placing widening material, and rolling.

Reflectorized barricades shall be placed along open trenches day and night. Lighting shall be placed at each barricade at night. Barricades and lights shall be approved by the Engineer. The barricades shall be placed at intervals not to exceed one hundred (100) meters or as directed by the Engineer.

The Contractor shall make adequate provision to enable traffic to cross open trenches at intersecting roads, streets and private entrances.

Partial shouldering shall be performed immediately after completion of widening of portions of the Work in order to eliminate the hazard.

No separate payment will be made for handling traffic which will be considered subsidiary to the item of "Pavement Widening."

210.5 MEASUREMENT AND PAYMENT

210.5.1 Measurement

"Pavement Widening" shall be measured by the unit of cubic meter and shall include all excavation, trimming, disposal and compaction of subgrade and subsequent layers of sub base and base course.

The removal of edge kerb if exists, will not be paid for separately but will be considered subsidiary to the item of "Pavement Widening".

Water, ordered by the Engineer or added with the consent of the Engineer, which is necessary to obtain satisfactory compaction of the foundation treatment will not be paid for separately, but will be considered subsidiary to the item of "Pavement Widening". No measurement will be made of unauthorized areas or for extra width or thickness.

210.5.2 Payment

The amount of completed and accepted Work, measured as provided above, will be paid for at the unit price bid in the Bill of Quantities for "Pavement Widening," which price shall be full compensation for furnishing materials, such as sub base, base course and water etc., for all labour, equipment, tools, supplies, and all other items necessary for the proper completion of the Work.

SECTION 211 LIME STABILIZED AGGREGATE BASE COURSE

211.1 DESCRIPTION

This work shall consist of performing all operations in connection with construction of "Lime Stabilized Aggregate Base Course" on the prepared Sub base or Sub grade surface and all incidentals in accordance with the specifications in conformity with the lines and level grade, and typical cross-sections shown on the plans.

211.2 MATERIAL REQUIREMENTS

211.2.1 Coarse Aggregate

Coarse Aggregates for crushed Lime stabilized Base Course shall be composed of hard, tough, sound durable crushed limestone, particles free from thin and elongated, soft and disintegrated material or other objectionable matters, complying with the following requirements.

Table 211-1: Crushed Stone Grading

Sieve Designation		Percent Passing by Weight
mm	Inch	
37.5	1.1/2	100
25.0	1	80-100
12.5	1/2	50-80
4.75	No. 4	30-60
0.425	No. 40	10-30
0.075	No. 200	5-15

The fraction of material passing 0.075 mm (No. 200 Sieve) shall not be more than 60% the fraction passing 0.425 mm (No. 40 Sieve).

Crushing of boulder on rock shall be regulated in such a way that fraction of aggregates retained on No. 40 (0.425 mm) sieve shall contain at least Ninety (90) percent by weight of crushed particles having more than one mechanical fractured faces.

The Abrasion loss of Crushed Lime Stone as determined by AASHTO T96-74 shall not exceed forty five (45) percent.

211.2.2 Fine Aggregate

The fraction of crushed aggregates passing No. 4 sieve shall consist of stone screenings free of loam, organic or other matter.

The material passing 0.425 mm (No. 40) sieve when prepared in accordance with AASHTO T 146-49 and tested by appropriate methods shall conform with the following requirement.

Liquid Limit	25% Maximum.
Plasticity Index	6 Maximum.

The calcium sulphate content of the fraction retained on sieve No. 4 shall not exceed ten (10) percent by weight.

211.3 CONSTRUCTION REQUIREMENTS

211.3.1 Equipment

All equipment, tools and machines used in the performance of the work shall be in good working condition and maintained all the times.

Blade graders, if used for spreading, the material shall have adjustable blades for slopes.

All sprinkling equipment shall be suitable for applying water uniformly and at controlled quantities to variable width of surface.

Transport vehicles carrying plant mix material shall have a capacity suited to the output of mixing plant and the site condition.

Mixing plant shall be of approved type, coordinated and operated so as to produce a mixture within required specification limit and shall have sufficient capacity.

211.3.2 Construction

Grade and alignment control stakes shall be furnished, set and maintained by the contractor in order that work shall conform to the lines, grade and cross-section shown on the drawings.

Material shall be placed and spread evenly using mechanical spreader. The spreader shall be adjustable so that width and thickness of the spreader can be set to any dimension required by the drawings and for uniform and complete coverage.

Aggregate shall be spread to loose thickness necessary to obtain the required compacted thickness of the layer.

Immediately after spreading and shaping operation, the mixture shall be thoroughly compacted with approved rollers. Water shall be applied to the materials during the rolling operation in such amount as may be required to obtain the specified density. In all the places not accessible to the rolling equipment, the material shall be compacted thoroughly with approved mechanical or hand tampers to density comparable to that obtained by rolling. The surface of the final layer shall be finished by blading and the addition of water, until the surface is smooth and free from waves and irregularities and is true to grade and cross-section. Where the thickness exceeds twelve and half (12.5) centimeters, it shall be compacted in two layers of equal thickness except that if vibratory roller is used for compaction, the layer thickness may be increased to maximum of twenty five (25) centimeters provided that satisfactory compaction is achieved.

Each layer shall be compacted until the entire depth of course is at least 95% of density at optimum moisture content as determined by AASHTO T 180-74. Compaction shall be completed as soon as possible after the material has been spread.

211.3.3 Thickness and Finish

Completed base course shall be tested for the required thickness and smoothness before acceptance. Any areas of the completed base course having compacted thickness less than the thickness shown on the drawing, or waves and irregularities as specified in the relevant, "Table for Allowable Tolerances", in these specifications shall be corrected by scarifying the surface, adding approved material, reshaping, recompacting and finishing as specified and as approved by the Engineer. Skin patching of an area without scarifying the surface to permit proper bonding of added material will not be permitted.

211.3.4 Maintenance

The completed base course shall be maintained in an acceptable condition at all times until prime coat is applied. When the base course is to carry traffic for an indefinite length of time before receiving the surfacing or pavement, the contractor shall maintain the surface until final acceptance and shall prevent raveling by wetting, blading, rolling and the addition of fines as may be required to keep the base tightly bound and leave a slight excess of material over the entire surface, which must be removed and the finish restored before the application of prime coat.

211.4 MEASUREMENT AND PAYMENT

211.4.1 Measurement

The unit of measurement for payment shall be in cubic meter of the completed and accepted crushed lime stone base course as measured in place. Measurement shall not include any area in excess of that shown on the drawings except the area authorized in writing by the Engineer. Measurement of lime used shall be the number of metric Ton consumed to stabilize base course. This quantity of lime used shall not exceed the theoretical percentage established in the laboratory.

211.4.2 Payment

Measured quantities of crushed limestone base course determined as above shall be paid for at the contract unit price per cubic meter for particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment; handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsuitable areas and unsatisfactory material; maintenance including protection of prepared base course and all incidentals necessary for completion of work except lime used which shall be paid separately as measured above.

SECTION 212 BITUMEN STABILIZED SUB-BASE OR BASE

212.1 DESCRIPTION

This work shall consist of performing all operation in connection with construction of bitumen stabilized sub base or base and all incidentals in conformity with the lines and level, grade, thickness and typical cross-section shown on the drawings or as directed by the Engineer.

212.2 MATERIAL REQUIREMENTS

If stationary plant is used for blending, all ingredients shall comply with any of the grading curve given in Table 212-2 whereas for mix in place method, in situ sand and gravel shall meet the gradation requirement as per Table 212-3 for bitumen stabilized Sub base or Base Course.

Coarse aggregate retained on 4.75 mm (No. 4) sieve shall consist of tough, hard and durable particles free from decomposed stone, organic matter and other deleterious substances.

Crushing of material shall be regulated such that material retained on 4.75mm (NO. 4) sieve shall have 50% by weight of total aggregates with at least two (2) mechanically fractured faces in case of bitumen stabilized sub base where as for bitumen stabilized base, material retained on No. 4 sieve shall have at least Ninety (90) percent by weight of total aggregate with two (2) mechanically fractured faces.

Aggregate retained on sieve No. 4 shall have a percentage of wear by Los Angles Abrasion Test as determined by AASHTO T-96 not more than forty five (45) percent in case of base course material and fifty (50) percent in case of sub-base material.

Fraction passing 0.075mm (No. 200) sieve shall not be greater than 2/3 rd of the fraction passing the 0.425mm (No. 40) sieve. The fraction passing 0.425 mm (No. 40) shall have a liquid limit not greater than 25% and plasticity Index not greater that 6.

If mineral aggregates contain moisture thus necessitating drying, bitumen material shall be of such nature that it will not foam when heated to hundred and eighty (180) degree centigrade and shall conform to requirements as shown in Table 301.2.

In dry areas, where natural moisture content of mineral aggregate is low bitumen binder shall be cut back conforming with the following requirements. Cut back shall meet the requirement of AASHTO M 81-70 and M 82-73 for rapid and medium curing type respectively. It shall comply with the requirements of AASHTO T 49-74, T 50-69, T 78-74 for the selected grade to suit the cutback as approved by the Engineer. Alternatively the bituminous binder shall be asphaltic cement of 80/100 penetration in summer and 120/150 in winter; bitumen emulsion of 80/100 penetration in summer and 150/180 penetration in winter. The bituminous emulsion shall comply with the requirements of AASHTO M 100-70 and be tested in accordance with AASHTO T 59-74.

Bitumen-Aggregate mixture for the grade of bitumen selected shall be ascertained by trial mixes using Marshal Method to determine the amount by weight of dry material, and using either heated or unheated aggregates as appropriate.

Table 212-1
Tentative Criteria for Bitumen-Aggregate Sub base / Base Material

Characteristic	Sub base	Base
Marshal Stability (Min)	250 Kg	400 Kg
Flow (Min)	2 mm	2 mm

Table 212-2: Selected Granular Sub base /Base Material-Grading

Sieve Designation		Percent Passing by weight		
mm	Inch	Type-A	Type-B	Type-C
75	3 inch.	100	---	---
50	2 inch.	90 -100	100	---
25	1 inch.	55 - 90	70-100	100
9.5	1/8 inch.	35 - 65	50-80	65-95
4.75	No. 4	25 - 55	40-65	50-80
2.0	No. 10	20 - 40	30-50	40-65
0.425	No. 40	10 - 25	15-25	20-35
0.075	No. 200	3 - 10	3-10	3-10

Table 212-3: Sand - Gravel Sub Base Material - Grading

Sieve Designation		Percent Passing by Weight
mm	Inch	
37.5	1.1/2 Inch.	100
25.0	1 Inch.	80-100
12.5	1/2 Inch.	50-80
4.75	No. 4	30-60
0.425	No. 40	10-30
0.075	No. 200	5-15

Fine aggregate passing 4.75 mm (No. 4 Sieve) shall consist of sharp natural sand, free from organic or other objectionable substances.

212.3 CONSTRUCTION REQUIREMENTS

All equipment, tools, machines used in the performance of work shall be in good working condition and be subject to the approval of the Engineer, and shall be maintained in satisfactory working condition at all times.

Blade grader if used shall have an adjustable blade for slopes and shall be self propelled.

212.3.1 Mix in Place Method of Construction

Mix in place method of construction may be adopted where the use of low viscosity binder i.e. Cutback or Bitumen emulsion are found suitable.

Grade and alignment control stakes shall be furnished, set and maintained by the contractor in order that work shall conform to the line, grade and cross-section shown on the drawings. The stakes shall be set in rows on and parallel to the center line of pavement and spaced so that string line may be stretched between them.

All material shall be placed evenly using mechanical spreader or spreader box operated with a mechanism which levels off the surface to an even depth.

Mixing shall be accomplished on one or more passes of the mixer through the material and shall be continued until the resulting mixture is entirely uniform and of proper moisture content. Moisture content, if less than required, shall be adjusted by sprinkling equipment, which shall be suitable for applying water uniformly and at controlled amount to variable depth of layer.

Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirement of specified, additional approved material shall be spread in such amounts as are found to be necessary and the added material shall be uniformly spread adding water if required to obtain the specified density.

212.3.2 Stationary Mixing Plant Method

Stationary plant method of construction will be used where stabilization with asphalt cement binder of penetration grade 80/100 is necessary.

The mixing plant shall be designed, coordinated and operated so as to produce mixture within required Job-Mix-Formula and shall have sufficient capacity. The plant shall be weigh batch type.

Transport vehicles carrying plant mix material shall have a capacity suited to the output of mixing plant and the site condition and be capable of discharging cleanly. Segregation of material shall be avoided.

212.3.3 Compaction

Immediately after spreading, shaping to required level, crown and grade, the mixture shall be thoroughly compacted with rubber or pneumatic tyred rollers. Compaction shall continue until the entire depth and width of Sub base/Base is uniformly compacted. Rolling shall begin at the low side and progress towards the higher side overlapping each preceding trip until entire surface has been rolled. Alternate trip of roller shall be of slightly different length. Roller shall be in good working condition, capable of reversing without back lash and shall be operated by skilled operator.

Compaction shall be checked on stabilized layer in accordance with ASTM-D 915-61 (1973). The bulk density of the mixture shall not be less than ninety eight (98) % of the laboratory bulk density. Deficient pavement shall be removed and replaced with satisfactory material.

212.3.4 Tolerance

Tolerance in the compacted layer shall be as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

212.3.5 Curing and Maintenance

After compaction, the stabilized Sub base/Base shall be protected against damage and maintained in an acceptable condition at all times prior to the construction of subsequent courses.

No vehicular traffic shall be allowed to pass on the stabilized surface for a minimum period of two (2) days.

212.3.6 Weather Limitations

Laying of bitumen stabilized base/sub base shall be avoided when air temperature is four degrees centigrade or below or when weather is rainy or foggy. Placing of mixture shall also be avoided when surface is wet or on any surface which is frozen or covered with ice or snow.

212.4 MEASUREMENT OF PAYMENT

212.4.1 Measurement

The unit of measurement for payment shall be cubic meter for the compacted and accepted bitumen stabilized sub base/base course as measured in place. Measurement shall not include any area except the area authorized in writing by the Engineer. Measurement of bitumen binder used shall be the number of metric Ton used to stabilize sub base or base course. The quantity of bitumen used shall not exceed the theoretical percentage established in the laboratory.

212.4.2 Payment

Measured quantity of stabilized Sub base/Base determined as above shall be paid for at the contract unit price per cubic meter for particular items listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing of labour, material, tool, plant, equipment, handling, mixing, manipulating, placing, shaping, compacting, rolling, finishing, correcting unsuitable areas and unsatisfactory material, maintenance including protection of stabilized Sub base/Base and all incidentals necessary for the completion of work except bitumen consumed which shall be paid separately as measured above.

SECTION 213 COLD RECYCLING OF ROAD PAVEMENT STRUCTURE/SOIL STABILIZATION.

213.1 DESCRIPTION

This item shall consist of breaking, removal, mixing, relaying and compaction of layers of surface, base and sub base course in a single operation. In this operation, addition of water or binder will also be required to add strength to the mix.

213.2 MATERIAL REQUIREMENTS

No fresh material is to be used as far as quarry materials are concerned. However, in order to achieve proper strength of the relayed material; water, cement or bitumen binder may be required to be added. Specification requirements of these ingredients shall be same as described under relative items of work. Cement and bitumen binder of following nomenclature shall be used.

i) Ordinary Portland cement (Type-I)

ii) Emulsified asphalt (RS-1, RS-2, SS-1, SS-1h)

213.3 CONSTRUCTION REQUIREMENTS

213.3.1 Equipment

Equipment utilized for this item of work shall ensure following activities in a single operation:

i) Breaking of layers in full depth in single operation.

ii) Pulverizing and mixing of different types of materials to give homogeneous mix.

iii) Mixing of water or bitumen binder in the total mass.

iv) Laying of treated material in smooth layer, keeping the grade and line as per design.

213.3.2 Cold Recycling of Asphalt

a. Milling Process

This work shall be carried out by specialized equipment designed to break and pulverize the asphaltic layer in a manner that maximum size of broken material reduces to basic size of aggregates. Asphaltic material lumps shall be reduced to a maximum size of fifteen (15) mm.

b. Additives

Bitumen binder (Emulsified Asphalt) shall be added to the mix through a computerized, electronically controlled unit for selecting and measuring the required amount. Bitumen binder and additives shall be added with pump and spray/injection system. Quantity of bitumen binder shall be controlled by programmable micro processors with respect to forward speed, milling depth, milling width and density of material.

c. Mixing and Laying

Milled materials and additives shall be mixed in a forced mixer to make the mass completely homogeneous. Material thus prepared shall be relayed through paving block having tamping and vibrating paving screeds. Paving screeds should be designed to provide initial compaction and shaping the surface to give the required grade and profile.

d. Compaction

Initial compaction shall be provided with paving screeds, however final compaction shall be carried out with conventional rolling equipment approved by the Engineer considering the type of material and thickness of recycled layer. However final compaction shall be checked after completion of rolling as determined by AASHTO T-230 method and shall not be less than ninety seven (97) percent of the Marshall density.

e. General

Total width of road asphalt shall be recycled in a number of strips, depending on width of recycling equipment and width of road. However all longitudinal and lateral joints shall be properly worked up to ensure smooth riding quality.

213.4 SOIL STABILIZATION

a. Milling Process

This work shall be carried out by specialized equipment designed to break and pulverize asphaltic layers and base and sub base courses to a depth of maximum three hundred (300) mm in a single operation. Breaking and pulverizing shall ensure reduction of binding material to reduce to a size of 50 mm (maximum) or to a smaller size depending on the thickness of relayed layer.

In case cement is to be used for improving the strength of relayed mix, the same shall be calculated and spread over the pavement structure before milling starts.

b. Additives

Water shall be added to the mix through a computerized, electronically controlled unit for selecting and measuring the required amount, water shall be added with pump and spray/injection system. Quantity of water shall be controlled by programmable micro processor with respect to forward speed, milling depth, milling width and density of materials.

c. Mixing and Laying

Milled materials and additives shall be mixed in a forced mixer to make the mass completely homogeneous. Material thus prepared shall be relayed through paving block having tamping and vibrating paving screed. Paving screeds should be designed to provide initial compaction and shaping the surface to give the required grade and profile.

d. Compaction

Initial compaction shall be provided with paving screeds, however final compaction shall be carried out with conventional rolling equipment approved by the Engineer considering the type of material and thickness of recycled layer. However final compaction shall be checked after completion of rolling as determined by AASHTO T-230 method and shall not be less than Ninety Five (95) percent of the modified proctor density.

e. General

Total width of road asphalt shall be recycled in a number of strips, depending on width of recycling equipment and width of road. However all longitudinal and lateral joints shall be properly worked up to ensure smooth riding quality.

213.5 MEASUREMENT AND PAYMENT

213.5.1 Measurement

The quantity of cold recycling or soil stabilization to be paid for shall be measured by the theoretical volume in cubic meter recycled as shown on the drawings or as directed by the Engineer, completed in place as per procedure detailed above. No allowance shall be given to material laid outside approved theoretical limits.

Measurement for bitumen binder shall be made in tons delivered to the equipment for work minus the balance left in the equipment.

Measurement for cement shall be made equal to the number of tons of cement delivered and laid over the pavement in manner described above.

213.5.2 Payment

The accepted quantities measured as provided above, shall be paid for at the contract unit price for each of the particular pay item listed below, which price and payment shall constitute full compensation for furnishing all materials, labour, equipments, tools and incidentals to complete the item.

Pay Item No.	Description	Unit of Measurement
213a	Cold recycling of Asphaltic layer	CM
213b	Soil Stabilization	CM
213c	Bitumen Binder (Asphaltic Emulsion)	Ton
213d	Cement Binder (O.P.C - Type-I)	Ton

SECTION 214 ASPHALTIC CONCRETE BINDER COURSE

214.1 DESCRIPTION

This work shall consist of furnishing and mixing aggregates and asphalt binder at a central mixing plant, transporting, spreading and compacting the mixture on a prepared base in accordance with these specifications and to the lines, grades and typical pavement sections shown on the Drawings or as directed by the Engineer.

214.2 MATERIAL REQUIREMENTS.

214.2.1 Aggregates.

Coarse and fine aggregates shall be clean, hard, tough, sound particles free from decomposed material, vegetable matter and other deleterious substances, and be of uniform quality, geology and petrology. Water borne material such as river bed gravel, if used, shall also conform to the above criteria.

Coarse aggregate, which is material retained on the No. 4 sieve, shall consist of crushed rock, crushed gravel or a mixture of natural and crushed gravel. The aggregate shall contain not more than 8% by weight of flats/or elongated particles (ratio maximum to minimum 5:1) and shall contain 100% angular material, such that all faces of each piece are fractured faces in cuboid shape.

Fine aggregate, which is material passing the No. 4 sieve shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock crust, hydrated lime, hydraulic cement or other suitable mineral matter and shall conform to the following gradation:

Table 214-1: Gradation of Filler Material

US Standard Sieve	Percent Passing by Weight
No. 30	100
No. 50	95-100
No. 200	70-100

The Coarse and fine aggregates shall meet the following requirements:

a) The percentage of wear by the Los Angles Abrasion test (AASHTO T 96) shall not be more than 40%.

b) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T 140) shall be less than 12%.

c) The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement should not be less than 45.

d) All aggregates shall have a liquid limit of not more than 25% and a Plasticity Index of not more than 4 as determined by AASHTO T-89 and T-90.

e) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 2.5:1).

214.2.2 Asphaltic Material

Asphaltic binder to be mixed with the aggregate to produce asphaltic base shall be as asphalt cement penetration grade 40-50, or 60-70 or 80-100, as specified by the Engineer. Generally it will meet the requirement of AASHTO M-20.

214.2.3 Asphalt Concrete Binder Course Mixture.

The composition of the asphaltic concrete paving mixture for binder course shall conform to class shown in the following table:

Table 214-2: Combined Aggregate Grading Requirements

Sieve Designation mm	Inch	Percent Passing by Weight
25	1	100
19	3/4	90-100
9.5	3/8	56-80
4.75	No. 4	35-65
2.38	No. 8	23-49
0.30	No. 50	5-19
0.075	No. 200	2-8

Asphalt Content Weight Percent of total mix.	**3.5 (minimum)**
The asphalt concrete binder course mixture shall meet the following Marshal Test Criteria:	
Compaction, number of blows each end of Specimen	75
Stability (Minimum)	1000 Kg.
Flow, 0.25 mm (0.01")	8-14
Percent air voids in mix.	4-8
Percent voids in mineral aggregate	according to article 5.3, MS-2, (Asphalt Institute USA) edition 1993
Loss of stability	25% (Max.)
Filler/Bitumen ratio	1-1.5 (applicable to hot climate (> 40 ^{o}C.)

214.2.4 Combined Aggregates Gradation.

Retained on No. 4	±	7.0%
Passing No. 4 to No. 100 sieves	±	4.0%
Passing No. 200	±	1.0%

Asphalt Content.

Weight percent of total mix.	±	0.3%

Should a change of sources of materials be made a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions made it necessary, a new Job Mix Formula will be required.

214.2.5 Job-Mix Formula.

At least one week prior to production, a Job-Mix Formula (JMF) for the asphaltic concrete course mixture or mixtures to be used for the project, shall be established jointly by the Engineer and the Contractor.

The JMF shall be established by Marshal Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), May 1992 Edition.

The JMF, with the allowable tolerances, shall be within the master range specified in Table 214-2. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregates.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto with the tolerances as per clause 214.2.4 of these specifications.

214.3 CONSTRUCTION REQUIREMENTS.

Construction requirements for this item shall conform with the same construction requirements specified for Asphaltic Concrete Base Course Plant Mix under Item 203.3, except as modified in the following sub-items.

214.3.1 Preparation of Base Course Surface.

Before spreading materials the surface of the previously constructed and accepted base course on which the mix is to be placed shall be conditioned by application of a tack/or prime coat, as directed by the Engineer.

214.3.2 Pavement Thickness and Tolerances.

The asphalt concrete binder course shall be compacted to the desired level and cross slope as shown on the drawings or as directed by the Engineer.

The tolerances in compacted thickness of the binder course shall be + 10 percent from the desired thickness shown on the drawings. For determination of the thickness, one (1) core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than + 10 percent, the Engineer shall decide whether to accept the deficit thickness or to direct reconstruction.

The surface of the binder course shall be tested by the Engineer using at 3-meter straight edge at selected locations. The variation of the surface from the testing edge of

the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point ± 5.0 millimeters. The cross fall (camber) shall be within ± 0.2 percent of that specified, and the level at any point shall be within drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective works and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer.

214.4 MEASUREMENT AND PAYMENT.

214.4.1 Measurement

The quantities of asphaltic binder course shall be measured on per cubic meter basis.

The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of liquid asphalt, wasted or remaining on hand after completion of the work, shall not be measured or paid for.

214.4.2 Payment

The quantities determined, as provided above, shall be paid for at the contract unit price respectively for each of the particular pay item listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
214	Asphaltic Concrete Binder Course.	CM.

SECTION 215 GEOTEXTILES

215.1 DESCRIPTION

The work covered by this section shall consist in furnishing all material, labour, equipment and placing of Geotextiles on prepared surfaces complete in accordance with the specifications for the work items involved, in thicknesses and to the dimensions shown on the typical cross-sections of applicable drawings or as directed by the Engineer.

215.2 GEOTEXTILE FUNCTIONS

Where indicated on the drawings or directed by the Engineer, Geotextile will be placed to perform one or more of the following functions.

- One road foundation for the purpose of separation between road fill material and soft underlying soils in order to eliminate the need for removal of poor subsoil material and quick and effective drainage of soil-fill interface.
- For subgrade stabilization and increasing soil shear strength by providing bonding mechanism of the Geotextile - soil system.
- As a filter for all drainage systems where a danger of clogging by fine particles of adjacent soil is possible. The geotextile will retain the particles from passing whilst allowing the seepage water to pass through.
- As a filter element for all bodies of water where the soil can be eroded by current, wave action or changing water levels.
- For permanent protection of synthetic sealing systems (Geomembranes) against mechanical damage during installation and after completion of construction.

215.3 MATERIAL REQUIREMENTS

215.3.1 Composition and Environmental Behavior

The raw material of geotextile shall be Ultra Violet stabilized polypropylene. The fibers shall consist of continuous filaments of approximately 40 micron diameter, and shall be mechanically bonded by needling or thermally bonded, as per manufacturer's recommendations. The geotextile material shall be resistant to acid and alkaline media in the pH range 2 to 13, resistant to lime, cement and concrete, resistant to all naturally occurring bacteria and fungi. A prolonged out side exposure of several months shall have no effect on the properties of Geotextile.

215.3.2 Mechanical and Hydraulic Properties

- To ensure free drainage, the geotextile shall have high water permeability with wide range of pore sizes and shapes.
- Geotextile shall offer high retention capability for almost all types of soils.
- The geotextile shall have optimum stress-strain behavior with low unit weight and high initial modulus, for high resistance against installation damage.

215.4 CONSTRUCTION REQUIREMENTS

215.4.1 Preparation

The surface shall be fairly leveled before placement of Geotextile. It is to be ensured that there are no protruding stones which may damage the geotextile fabric.

215.4.2 Geotextile Placement

The Geotextile shall be rolled out directly on top of the prepared surface in a manner as recommended by the manufacturer. It shall be over lapped at the edges as shown on the drawings or as recommended by the manufacturer.

215.4.3 Placement of fill

The first layer of fill material shall be applied by overhead placement. Traffic on the geotextile itself shall be avoided. Necessary precautions shall be observed to ensure that geotextile shall not be damaged during placement.

215.4.4 Spreading

Spreading of fill material shall be done with suitable equipment and procedure ensuring that geotextile must not be damaged by high axle load stresses of spreading equipment traveling on sharp fill over the geotextile.

215.4.5 Compaction

The compacting method (Static/Dynamic) shall be suited to subgrade/fill material.

215.4.6 Jointing of Geotextile Panels

A tension joint shall be achieved by overlapping, welding or sewing as shown on drawings or approved by the Engineer.

i) Overlapping

Overlapping width shall not be less 30 cm on even surface and 50 cm on uneven surface. In order to avoid displacing the geotextile during backfill over end panel joints, the connecting panel must be placed underneath the end of the previously rolled out geotextile.

ii) Welding

To weld the geotextile, an overlap of 10 to 15 cm wide shall be maintained. An automatic thermal welding wedge welder with either a solid or dual track wedge shall be used to weld the geotextile. In locations with limited access for a wedge welder, a hand held hot air blower with a 40mm wide end nozzle shall be used along with a rubber tipped hand roller of 40mm width being continuously pressed by hand to put pressure on the welded area as the welding progresses.

iii) Sewing

The stitching method shall be single thread, double thread or butterfly type suitable to geotextile thread type and strength. The thread shall be sufficiently tightened and stitch density shall be three to six stitches per inch.

215.5 GEOTEXTILE FUNCTION FOR REPAVING

This section deals with geotextiles placed between old pavement and new asphalt overlay, along with suitable tack coat of bitumen. Where indicated on drawings or directed by the Engineer, geotextile will be placed to perform one or more of the following functions.

- To ensure proper adhesion between old pavement and new asphalt overlay & thus reducing the over all flexural tensile stresses and increasing life of road surface.
- As a cut off layer for the prevention of propagation of cracks in the pavement.
- As water barrier, even under high pressure to stop reflective cracking in the pavements.

215.5.1 Construction Requirements

- Removal of dirt, dust and vegetation from wearing surface and cracks.
- Filling potholes and larger cracks (>5mm) with hot mix or an adequate filler.
- Removal of sharp or craggy edges on surface.
- On badly damaged roads, a level course of approx. 1,5 cm shall be laid to avoid the labour intensive and time consuming operation of crack filling.

215.5.2 Applying the tack coat

Depending on the condition of the old surface, a calculated amount of tack coat (Q_{ef}) of approx. 1.1 kg/m^2 active binder is to be sprayed evenly on the prepared surface before laying geotextile, making sure that:-

- The bitumen is applied beyond the width of the geotextile by about 5 cm on either side.
- The spraying temperature for pure bitumen is kept between 150 ^oC and 170^oC to achieve a coating as even as possible.
- When using bitumen emulsion, the coating amount is adjusted to contain the required average amount of bitumen.
- The coating is only applied to areas where the paving felt is to be laid.
- No additional pre-spray agent is applied on top of the paving felt.
- Where only sections for the road are covered with the paving felts, their surfaces must be gritted.

215.5.3 Laying Geotextile

Geotextile shall be laid by hand or machine taking into account that;

- When using pure bitumen as tack coat, Geotextile may be laid immediately after coating.
- When using bitumen emulsions, Geotextile shall not be laid until the emulsion has cured.
- Wrinkles shall be avoided.
- Edges lengthways and across overlap by 5-10 cm, an additional pure bitumen binder of 0.9 kg/m^2 shall be applied on the overlapping seams.
- Transverse overlapping is to be carried out with reference to the direction in which the asphalt finisher will proceed i.e. under the previous one so that the felt does not shift out of place when the asphalt concrete is applied.
- When one half of the road is made (leaving the other open to traffic), at least 25cm of the lengthways felt edge shall remain uncovered to allow overlapping when laying the other half of the road.
- During short time stoppages of construction work, the road under construction shall be opened only to slow traffic without detriment to Geotextile.
- Rain water on the Geotextile surface shall be allowed to evaporate before applying a top layer.

215.5.4 Applying the asphalt concrete surface

The asphalt concrete surfacing shall be applied immediately after laying Geotextile preferably by crawler type finisher, taking the following points into consideration.

- The material mix shall have a temperature between 145 ^oC and 165^oC

- To avoid types of the finisher or truck sticking to the felt (which can happen in hot climates or where too much tack coat has been applied), some of the mix can be spread manually in the pathway of the vehicles.

215.6 GEOTEXTILE TESTING

Geotextiles testing shall be in accordance with following standard test methods.

Properties	**Standard**
Durability - Oxidation Resistance (%)	EN ISO 13438
Mass per unit Area	EN ISO 9864
Thickness under 2 kN/m^2	EN ISO 9863-I
Mechanical Properties	
Energy Absorption	EN ISO 10319
Tensile Strength	ASTM D4595
Elongation	ASTM D4595
Strength at 5% Elongation	ASTM D4595
Grab Strength	ASTM D-4632
Puncture Strength CBR	EN ISO 12236
Dynamic Cone Puncture	EN 918
Tear strength	ASTM D4533
Puncture Resistance	ASTM D4833
Hydraulic Properties	
Opening Size O_{90} Wet	EN ISO 12956
Opening Size O_{95} Dry	ASTM D4751
Permittivity	ASTM D4491
Permeability Velocity index (VH50)	EN ISO 11058
Permeability at 20 kN/m^2	DIN 60500-4
Permeability at 200 kN/m^2	DIN 60500-4

Based on the required functions and the type of stresses, the contractor shall propose the type of Geotextile. The contractor shall furnish technical literature and Manufacturer's Certificate of Guarantee for the type of geotextile material for approval of Engineer prior to delivering the material to the site. The certificate shall note compliance to the specifications and shall state the results of the tests performed on the material, as required by the specifications. The Contractor shall, when directed by the Engineer, have the Geotextile material tested for conformance to the applicable specifications at an approved testing laboratory. All costs connected with certificate of Guarantee and any subsequent quality testing shall be at the contractor's expense.

215.7 MEASUREMENT AND PAYMENT

215.7.1 Measurement

The quantity of Geotextile measured to be paid shall be the number of square meters of work completed in accordance with requirement of this item and the limiting dimensions shall not exceed than those shown on the drawings or fixed by the Engineer. Measurement shall only be made of area covered without considering any overlap.

215.7.2 Payment

The accepted quantity measured as provided above shall be paid at the contract unit price per square meter of Geotextile laid for the pay item as listed below in the BOQ which price and payment shall constitute full compensation for furnishing all materials, labour, equipment and placing of geotextile.

Pay Item No.	**Description**	**Unit of Measurement**
215	Providing and Placing of Geotextile, type------.	SM

SECTION 216 SOLING STONE

216.1 DESCRIPTION

This item shall consist of laying of soling stone, hand packed on a surface (subgrade) prepared earlier and all interstices filled with sand or similar approved materials to provide proper bonding of all the stones with each other.

216.2 MATERIAL REQUIREMENTS

The material for soling shall be round and durable rock, properly shaped or boulders of size 15-20 cm. The filler material to fill the interstices shall be coarse sand or rock dust or any other material approved by the Engineer. Material shall be cohesion less and clean to allow its free flow down to the bottom of soling area.

216.3 CONSTRUCTION REQUIREMENT

216.3.1 The subgrade to receive the soiling stone shall be prepared under relative item of the work.

216.3.2 Placing of Soling Stone

The soling stone shall be placed from outer edges of the road and finishing at the crown of the road in such a way that all stones are properly hand packed and keyed with the surrounding stones. It shall be ensured that the maximum dimension is kept in vertical position ensuring the variation of the size of the stone does not exceed $\pm$ 1" of specified thickness of soling stone:

The filler material shall be dry and in free flow condition when placed over the soling stone. The filler material shall be kept adding while the soling stones are rolled under a 6 tons roller. The addition of filler material shall continue till the area does not absorb more material and it is ensured that all interstices are fully filled. The area will than be watered and kept under rolling to achieve a smooth surface.

216.4 MEASUREMENT AND PAYMENT

216.4.1 Measurement

The area to be measured shall be bound by the lines shown on the drawings whereas the normal thickness shall be that which is described in BOQ. The measurement shall be made in CM.

216.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price for cubic meter which price and payment shall be full compensation for all cost of materials, manpower and equipments involved in the proper completion of work.

Pay Item No.	Description	Unit of Measurement
216 a	Providing and laying stone soling 6" thick of approved quality to required grade and camber of road including filling stone dust, chips, spawls, watering and compaction , complete in all respect.	CM

SECTION 217 INTERLOCKING CONCRETE PAVING BLOCKS

217.1 DESCRIPTION

The work shall consist of precast concrete paving blocks intended for the construction of low speed roads, parking areas, lay byes, industrial and other paved surfaces subjected to all categories of static and vehicular loading and pedestrian traffic. Paving blocks covered by these Specifications are designed to form a structural element and the surfacing of pavements, having the block to block joints filled, so as to develop frictional interlock and placed in conformity with the lines, grades, thicknesses and typical cross-section shown on the drawings or as directed by the Engineer.

217.2 MATERIAL REQUIREMENTS

For execution of this item provisions made in BS 6717 shall be applicable. Detailed requirement of materials and construction shall be as under:

217.2.1 Binders and Binder Constituents

Paving blocks shall be made using one or more of the following binders or binder constituents complying with the requirements of the relevant standards:

Ordinary Portland Cement	BS 12 or ASTM C-150
Portland Blast furnace Cement	BS 146:Part2 or ASTM C-595
Portland Pulverized Fly ash Cement	BS 6588 or ASTM C-595
Pulverized Fly ash	BS 3892:Part1 or ASTM C-311
Ground Granulated Blast furnace slag	BS 6699 or ASTM C-989

Where pulverized fuel/fly ash is used, the proportions and properties of the combination with Portland cement shall comply with BS 6588 or ASTM C-595.

Where ground granulated blast furnace slag is used, the proportions and properties of the combination with Portland Cement shall comply with BS 146:Part 2. or ASTM C-595

217.2.2 Aggregates

Paving blocks shall be made using one or more of the following aggregates complying with the relevant standards:

Natural Aggregates (Crushed or Uncrushed)	BS 882:1983 (except grading requirements in clause 5) or ASTM C-33 (except grading requirements)
Air Cooled blast furnace slag	BS 1047:1983 (except grading requirements in 4.8)
Pulverized fuel ash	BS 3892:Part-1 or Part-2 or ASTM C-311
Ground granulated blast furnace slag	BS 6699 or ASTM C-989

217.2.2.1 Acid Soluble Material (Fine Aggregate)

When tested as described in BS 812 : Part 119, the fine aggregate (material passing a 5 mm sieve complying with BS 410) shall contain not more than 25% by mass of acid soluble material either in the fraction retained on, or in the fraction passing, a 600 μ m sieve.

217.2.3 Water

The water shall be of drinking quality or in accordance with the recommendations of appendix A of BS 3148: 1980.

217.2.4 ADMIXTURES AND PIGMENTS

Proprietary accelerating, retarding and water reducing agents shall comply with BS 5075: Part 1.

Pigments shall comply with BS 1014.

Calcium chloride shall comply with BS 3587

217.2.5 FINISHES

The finish should be agreed between the manufacturer and the Engineer.

Concrete described as “natural colour” shall contain no pigment.

In composite paving blocks the surface layer shall be formed as an integral part of the block and shall be not less than 5 mm thick.

217.2.6 BINDER CONTENT

The cement content of the compacted concrete shall be not less than 380 kg/m^3. For equivalent durability, paving blocks made with binder constituents other than ordinary Portland cement shall have a higher binder content than paving blocks made in a similar way using only Portland Cement. The Engineer will decide the additional binder content. The compressive strength test will be the only guide to the amount of additional binder needed.

217.2.7 SIZES AND TOLERANCES

217.2.7.1 Sizes

Paving blocks shall have a work size thickness of not less than 60 mm. Type-R blocks shall be rectangular with a work size length of 200 mm and a work size width of 100 mm. Type-S blocks shall be of any shape fitting within a 295 mm square coordinating space and shall have a work size width not less than 80 mm.

The preferred work size thicknesses are 60 mm, 65 mm, 80 mm & 100 mm.

A chamfer around the wearing surface with a work size not exceeding 7 mm in width or depth shall be permitted.

All arrises (sharp edges formed at joints of blocks) shall be of uniform shape.

217.2.7.2 Tolerances

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as follows:

length	$\pm$ 2 mm
width	$\pm$ 2 mm
thickness	$\pm$ 3 mm

Where a paving block includes profiled sides, the profile shall not deviate from the manufacturer’s specification by more than 2 mm.

217.2.8 COMPRESSIVE STRENGTH

The compressive strength of paving blocks shall be not less than 49 N/mm^2 and the crushing strength of any individual block shall be not less than 40 N/mm^2.

217.2.9 SAMPLING

The following sampling procedure shall be used for the compressive strength test.

a) Before laying paving blocks, divide each designated section, comprising not more than 5000 blocks, in a consignment into eight approximately equal groups, Clearly mark all samples at the time of sampling in such a way that the designated section or part thereof and the consignment represented by the sample are clearly defined. Take two (2) blocks from each group.

b) Dispatch the sample to the test laboratory, taking precautions to avoid damage to the paving blocks in transit. Each sample shall be accompanied by a certificate from the person responsible for taking the sample, stating that sampling was carried out in accordance with this Part of BS 6717.

c) Protect the paving blocks from damage and contamination until they have been tested. Carry out any tests as soon as possible after the sample has been taken.

217.2.10 MARKING

The following particulars relating to paving blocks made in accordance with this standard shall be indicated clearly on the delivery note invoice, manufacturer's or supplier's certificate or brochure supplied with the consignment of blocks:

a) The name, trade mark or other means of identification of the manufacturer.

b) The number and date of this British Standard, i.e. BS 6717 : Part 1 : 1986*; or latest revision.

217.3 CONSTRUCTION REQUIREMENTS

217.3.1 Laying the Concrete Blocks

The total area to be covered with paving block shall be prepared by:
a) Compaction of subgrade
b) Laying of sub base in a thickness specified
c) Laying of crushed aggregate base or lean concrete in thickness as per typical section

217.3.2 Tolerance

Tolerance of these layers shall be as per applicable requirement of each item of these specifications.
Payment for each of the above item shall be made under the relative item of work.
The total area will thereby be divide with nylon strings into sectors of not more than 1.5 square meters. This shall be done to control the alignment of paving blocks and to avoid multiplication of deviation in sizes of paving blocks.

217.4 MEASUREMENT AND PAYMENT

217.4.1 Measurement

The area to be measured shall be bound by lines shown on the drawings or as directed by the Engineer. Unit of measurement shall be square meter measured in horizontal plane.

217.4.2 Payment

The quality determined as provided above shall be paid for the unit price of contract for each square meter of paving block installed including sand cushion and sand filling in joints and all other work related for installing paving blocks. Cost shall include all labour, materials and equipment for proper completion of work.

SURFACE COURSES
AND
PAVEMENT

SURFACE COURSES AND PAVEMENT

SECTION 300 GENERAL

This section describes the requirements and procedures for execution of surface courses and pavements. The materials to be used shall conform to specifications and testing procedures as per American Association of State Highway and Transportation Official (AASHTO) or the American Society for Testing and Material (ASTM) as indicated in their latest editions. Samples of materials for laboratory tests and their subsequent approvals shall be utilized according to these references unless otherwise directed by the Engineer.

Materials which do not conform to the requirements of these specifications will be rejected, whether in place or not. They shall be removed immediately from the site of the work at the expense of contractor. While sub grade/sub base and paving operations are in progress, a detour shall be provided for vehicular flow in order to avoid any public inconvenience and thoroughly be maintained till completion of that particular section of the project or as a whole. In order to expedite the passage of public traffic through or around the work, the contractor shall install road signs, warning lights, flares, barricades and other facilities for the safety, convenience and direction of public traffic. Also where directed by the Engineer, the contractor shall furnish competent flagmen whose sole duties shall consist of directing the movement of public traffic through or around the work. The cost of furnishing and installation of such road-signs, lights, flares barricades and other facilities, shall be included in the respective work item. Should the Engineer point out the inadequacy of warning and protective measures, and require additional measures, such action on the part of the Engineer shall not relieve the contractor from responsibility for public safety or abrogate his obligation to furnish and pay for these services.

SECTION 301 ASPHALTIC MATERIALS

301.1 ASPHALT CEMENT

Asphalt Cement shall be an oil asphalt, or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude asphaltic petroleum. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar, or paraffin and shall be homogeneous and free from water. No emulsification shall occur when a thirty (30) gram sample is boiled for two (2) hours with two hundred and fifty (250) cubic centimeters of distilled water in a five hundred (500) cubic centimeters Erlenmeyer flask equipped with a reflux condenser.

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalts shall conform to the requirements set forth in Table 301-3. The grade of asphalt to be used shall be in accordance with these specifications or the Special Provisions or as directed by the Engineer.

301.2 ENVIRONMENTAL FACTORS

In areas where highly frost susceptible soils and severe low temperature conditions are encountered, it may be necessary to remove and replace soils susceptible to frost heave or take other precautions prior to pavement construction. In extremely hot climates, asphalt mixes should be designed to resist rutting and maintain stiffness at high temperatures.

Because asphalt mixtures are influenced by temperature, it is recommended that different asphalt grades be used where different temperature conditions prevail. Table below gives recommended asphalt grades for various temperature conditions.

TABLE 301-1: SELECTING ASPHALT GRADE

Temperature Condition	Asphalt Grade
Cold, mean annual air temperature $\leq$ 7 °C (45 °F)	AC-10 AR-4000 80 / 100 pen
Warm, mean annual air temperature between 7 °C (45 °F) and 24 °C (75 °F)	AC-20 AR-8000 60 / 70 pen.
Hot, mean annual air temperature $\geq$ 24 °C (75 °F)	AC-40 AR-16000 40 / 50 pen.

301.3 CUT-BACK ASPHALT

Liquid asphalts (cut back) shall consist of materials conforming to the following classifications. When tested in accordance with the standard methods of tests of the AASHTO, the grades of liquid asphalt shall conform to the requirements specified in the Table 301-3 and 301-4.

Medium curing products designated by letters MC, shall consist of asphalt cement fluxed or blended with a kerosene solvent.

Rapid curing products designated by the letters RC, shall consist of asphalt cement with a penetration of grade 80-100, fluxed or blended with a naphtha solvent.

301.4 EMULSIFIED ASPHALT

Asphaltic emulsions shall be composed of a bituminous base uniformly emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting, Medium Setting, Slow Setting, or Quick Setting and shall conform to the requirements specified in Item 313 (Tables 313-1 and 313-2) of this specification.

Emulsified Asphalts can be either of the two types: cationic (ASTM D 2397 or AASHTO M 208) or anionic (ASTM D977 or AASHTO M 140). Selecting one of the two shall depend on the type of aggregate used for better affinity.

The grade of emulsified asphalt is selected primarily on the basis of its ability to satisfactorily coat the aggregate. This is determined by coating and stability test (ASTM D 244, AASHTO T 59). Other factors important in the selection are the water availability at the job site, anticipated weather at the time of construction, the mixing process to be used, and the curing rate.

301.5 POLYMER MODIFIED ASPHALT

Polymer Modified Asphalts are asphalts whose properties pertaining to deformation resistance and fatigue characteristics are enhanced by addition of polymers. Polymer Modified Asphalts shall consist of Thermoplastic Elastomers or Thermoplastic Polymers blended with neat Bitumen. Polymer Modified Asphalt corresponding to one of the following types shall be used as specified or directed by the Engineer.

1. Type-I polymer-modified asphalts made with styrene-butadiene or styrene-butadiene-styrene block copolymers, conforming to ASTM D-5976

2. Type-II polymer-modified asphalts made with styrene-butadiene rubber latex or polychloroprene latex, conforming to ASTM D-5840.

3. Type-III polymer-modified asphalts made with ethyl vinyl acetate conforming to ASTM D-5841.

However, any other polymer may be used after approval from the Engineer, that will give the required test results as per one of the above three types, when blended with the desired asphalt.

The blending of the asphalt and polymer modifier to form polymer modified asphalt shall take place through the use of a high speed Siefer mill. The modifier to be added to bitumen shall have following characteristics:

- It shall resist degradation at asphalt mixing temperatures.
- It shall blend with Bitumen.
- It shall improve resistance to flow at high road temperatures without making the bitumen too viscous at mixing and laying temperatures or too stiff or brittle at low temperatures.

After blending with bitumen the modifier shall have following characteristics:

- It shall maintain its premium properties and shall be stable chemically during storage, application and in service.
- It shall be capable of being processed by conventional equipment.
- It shall achieve a coating or spraying viscosity at normal application temperatures.

Compatibility Test:

Polymer Modified Asphalt, when tested according to EN 13399 “Bitumen and bituminous binders - Determination of storage stability of modified bitumen”, shall have

a difference in softening point of less than five (5) deg C, between samples taken from top and bottom of the container.

A difference of five (5) deg C or more in softening point shall depict incompatibility of polymer and asphalt, and hence shall be the cause of rejection.

APPLICATION TEMPERATURES

TABLE 301-2

Application Temperature Range, ^{O}C

Asphalt Type	Grade	Mixing Temp	Spraying Temperature Road Mixes
a. Asphalt Cement	All grades	As required to achieve viscosity of 75-150 seconds Saybolt-Furol. Or as required to achieve a Kinematic Viscosity of 150-300 centistokes.	160 (Max)
b. Emulsified Asphalts	RS-1	–	20-60
	RS-2	–	50-85
	MS-1	10-70	20-70
	MS-2	10-70	20-70
	MS-2h	10-70	20-70
	HFMS-1	10-70	20-70
	HFMS-2	10-70	20-70
	HFMS-24	10-70	20-70
	SS-1	10-70	20-70
	SS-1h	10-70	20-70
	CRS-1	10-70	50-85
	CRS-2	–	50-85
	CMS-2	–	20-70
	CMS-2h	10-70	20-70
	CSS-1	10-70	20-70
	CSS-1h	10-70	20-70
c. Cutback Asphalts (RC, MC, SC)	30 (MC only)	–	–
	70	–	20 min.
	250	55-80	40 min.
	800	75-100	55 min.
	3000	80-115	–

TABLE 301-3

REQUIREMENTS FOR ASPHALT CEMENT (AASHTO M-20)

	Penetration Grade							
	40 - 50		60 - 70		80 - 100		120 - 150	
	Min.	Max.	Min.	Max.	Min.	Max.	Min	Max
Penetration at 77° F (25 °C) 100g 5 sec.	40	50	60	70	80	100	120	150
Flash point, Cleveland Open Cup, ° F(°C)	450 (232)	- -	450 (232)	- -	450 (232)	- -	425 (218)	- -
Ductility at 77 °F (25 °C) 5cm per min, cm.	100	-	100	-	100	-	100	-
Solubility in trichloroethylene percent.	99	-	99	-	99	-	99	-
Thin-film oven test, 1/8 in. (3.2mm), 325 °F (163 °C) 5 hr Loss on heating, percent.	-	0.80	-	0.80	-	1.0	-	1.3
Penetration, of residue, percent of original.	58	-	54	-	50	-	46	-
Ductility of residue at 77 °F (25°C) 5 cm. per min., cm.	-	-	50	-	-	-	100	-

TABLE 301-4

REQUIREMENTS FOR MEDIUM-CURING TYPE ASPHALTS (AASHTO M-82)

	MC - 70		MC - 250		MC - 800	
	Min.	Max.	Min.	Max.	Min.	Max.
Water, percent	-	0.2	-	0.2	-	0.2
Flash point (tag. Open cup), Degree C	38	-	66	-	66	-
Kinematic Viscosity at 60°C (140°F) (See Note 1) Centistokes	70	140	250	500	800	1600
Distillation test:						
Distillate, percentage by volume of total distillate at 360°C (680°F)						
at 225°C (437°F)	0	20	0	10	-	-
at 260°C (500 °F)	20	60	15	55	0	35
at 315 °C (600 °F)	65	90	60	87	45	80
Residue from distillation at 360 °C (680 °F) Volume percentage of sample by difference	55	-	67	-	75	-
Tests on residue from distillation:						
penetration, 100g., 5 sec., at 25 °C (77 °F)	120	250	120	250	120	250
Ductility, 5 cm/min, cm (see note 2)	100	-	100	-	100	-
Solubility in Trichloroethylene, percent	99.0	-	99.0	-	99.0	-

Note: **1.** As an alternate, Saybolt Furol vicosities may be specified as following:

Grade MC-70 Furol Viscosity at 50°C (122°F) - 60 to 120 Sec.

Grade MC-250 Furol Viscosity at 60°C (140°F) - 125 to 250 Sec.

Grade MC-800 Furol Viscosity at 82.2°C (180°F) - 100 to 200 Sec.

2. If penetration of residue is more than 200 and its ductility at 25°C (77 °F) is less than 100 cm., the material will be acceptable if its ductility at 15.5 °C (60 °F) is more than 100 cm.

TABLE 301-5

REQUIREMENTS FOR RAPID-CURING TYPE ASPHALTS (AASHTO M-81)

	RC - 70		RC - 250		RC - 800	
	Min.	Max.	Min.	Max.	Min.	Max.
Water, percent	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup), Degree C	-	-	27	-	27	-
Kinematic Viscosity at 60°C (140°F) (See Note 1) Centistokes	70	140	250	500	800	1600
Distillation test:						
Distillate, percentage by volume of total distillate at 360°C (680°F)						
at 190°C (374°F)	10	-	-	-	-	-
at 225°C (437°F)	50	-	35	-	15	-
at 260°C (500 °F)	70	-	60	-	45	-
at 315 °C (600 °F)	85	-	80	-	75	-
Residue from distillation at 360 °C (680 °F) Volume percentage of sample by difference	55	-	65	-	75	-
Tests on residue from distillation:						
penetration, 100g: 5 Sec., at 25 °C (77 °F)	80	120	80	120	80	120
Ductility, 5 cm/min, of 25 °C (77 °F) cm	100	-	100	-	100	-
Solubility in Trichloroethylene, percent	99.0	-	99.0	-	99.0	-

Note: As an alternate, Saybolt Furol vicosities may be specified as following:

Grade RC-70 Furol Viscosity at 50°C (122°F) - 60 to 120 Sec.
Grade RC-250 Furol Viscosity at 60°C (140°F) - 125 to 250 Sec.
Grade RC-800 Furol Viscosity at 82.2°C (180°F) - 100 to 200 Sec.

TABLE 301-6

PHYSICAL PROPERTY REQUIREMENTS FOR TYPE-I POLYMER-MODIFIED ASPHALTS

Designation	I-A		I-B		I-C		I-D	
	min	max	min	max	min	max	min	max
Penetration, 25°C (77°F), 100 g, 5 s, dmm	100	150	75	100	50	75	40	75
Viscosity, 60°C (140°F), 1 s^{-1}, poise[A]	1250		2500		5000		5000	
Viscosity, 135°C (275°F), cSt		2000		2000		2000		5000
Flash Point, COC, °C	232		232		232		232	
Solubility in trichloroethylene, %	99		99		99		99	
Separation, difference, °C		2.2		2.2		2.2		2.2
Tests on RTFOT Residue[B]								
Elastic recovery, 25°C (77°F), 10 cm elongation, %	60		60		60		60	
Penetration, 4°C (39.2°F), 200 g, 60 s, dmm	20		15		13		10	

[A] The absolute viscosity should be run in a modified Koppers or Asphalt Institute vacuum capillary viscometer. Report the viscosity at a shear rate of 1 reciprocal second.
[B] The thin film oven test may be used, but the rolling thin film test shall be the referee method.

TABLE 301-7

PHYSICAL PROPERTY REQUIREMENTS FOR TYPE II POLYMER MODIFIED ASPHALTS

Designation	II-A		II-B		II-C		II-D	
	min	max	min	max	min	max	min	max
Tests on Original Product								
Penetration at 25°C, 100 g, 5 s	100		70		85		80	
Viscosity, 60°C, 1s^{-1}, poise	800		1600		800		1600	
Viscosity, 135°C, cSt	300		300		300		300	
Ductility, 4°C, 5 cm/min, cm	50		50		25		25	
Flash Point, COC, °C	232		232		232		232	
Toughness, 25°C, 51 cm/min, mN-m	8475		12430		8475		12430	
Tenacity, 25°C, 51 cm/min, mN-m	5650		8475		5650		8475	
Tests on Aged Residue [A]								
Ductility, 4°C, 5 cm/min, cm	25		25		10		10	
Viscosity, 60°C, 1s^{-1}, poise		4000		8000		4000		8000
Toughness, 25°C, 51 cm/min, mN-m					8475		11300	
Tenacity, 25°C, 51 cm/min, mN-m					5650		8475	

[A] The thin-film oven test or the rolling thin-film test may be used.

TABLE 301-8

REQUIREMENTS FOR TYPE III POLYMER MODIFIED ASPHALT

Designation	III-A		III-B		III-C		III-D		III-E	
	min	max	min	max	min	max	min	max	min	max
Penetration at 4°C, 200g, 60s	48		35		28		22		18	
Penetration at 25°C, 100g, 5s	30	150	30	150	30	150	30	150	30	150
Viscosity, 135°C, cSt	150	1500	150	1500	150	1500	150	1500	150	1500
Flash Point COC, °C	218		218		218		218		218	
Softening Point, R and B, °C	52		54		57		60		63	
Separation, 135°C, 18h	Homogeneous									
Solubility in TCE,%	99		99		99		99		99	
RTFOT Residue[A]										
Penetration, 4°C, 200g, 60s	24		18		14		11		9	
Loss, %		1.0		1.0		1.0		1.0		1.0

[A] Thin-film oven test may be used, but rolling thin-film test shall be referee method.

SECTION 302 BITUMINOUS PRIME COAT

302.1 DESCRIPTION

This work shall consist of furnishing all plant, labour, equipment, material and performing all operations in applying a liquid asphalt prime coat on a previously prepared and untreated; earth sub grade, water bound base course, crushed aggregate base course, tops of roadway shoulders, and as otherwise shown on the plans in strict accordance with the specification and in conformity with the lines shown on the drawings.

302.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of the item 301 - "Asphaltic Materials", either cutback or Emulsified Asphalt, which ever is specified in the Bill of Quantities.

302.3 CONSTRUCTION REQUIREMENTS

Prime coat shall be applied when the surface to be treated is dry; except that when emulsified asphalt is used, the surface may be reasonably moist. The application is prohibited when the weather is foggy or rainy, or when the atmospheric temperature is below fifteen (15) degree C unless otherwise directed by the Engineer. Prior to the application of the prime coat, all loose materials shall be removed from the surface and the same shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dust as is deemed practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. Prior to the application of prime coat on bridge decks and concrete pavements, the surfaces shall be cleaned of all loose material as described in Section 302.3. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer. Areas to be primed will be classified as under:

(i) The top of earth surface or water bound base courses from a point twenty (20) centimeters outside the edge of the pavement line to 20 cms outside the line on the opposite side of the roadway.

(ii) The top of the shoulders from the inter-section of embankment slope and top of subgrade to the edge of the pavement line.

(iii) The bridge wearing surface from curb to curb and end to end of bridge wearing surface.

(iv) Other surfaces as shown on the plans or ordered by the Engineer.

Primed surface shall be kept undisturbed for at least 24 hours, so that the bituminous material travels beneath and leaves the top surface in non-tacky condition. No asphaltic operations shall start on a tacky condition.

302.3.1 Equipment

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 1000 litre capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed hundred (100) Kg per cm width of tyre. It shall be of recognized manufacturer.

The tank shall have a heating device able to heat a complete charge of asphaltic liquid up to one hundred eighty (180) degree C. The heating device shall be so that overheating will not occur. Consequently, the flames must not touch directly on the casting of the tank containing the asphaltic liquid or gases therefrom. The Contractor will be responsible for any fire or accident resulting from heating of bituminous

materials. The liquid shall be circulated or stirred during the heating. The tank shall be insulated in such a way that the drop in temperature when the tank is filled and not heated, will be less than two (2) degree C per hour. A thermometer shall be fixed to the tank in order to be able to control continuously the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in the tank is measured. The tank shall be furnished with a device that indicates the contents. The pipes for filling the tank shall be furnished with an easily interchangeable filter.

The distributor shall be able to vary the spray width of the asphaltic liquid in steps of maximum 10 cm, to a total width of four (4) M. The spraying bar shall have nozzles from which the liquid is sprayed fan-shaped on the road surface equally distributed over the total spraying width.

The distributor shall have a pump for spraying the liquid driven by a separate motor, or the speed of the pump shall be synchronized with the speed of the distributor. The pump shall be furnished with an indicator showing the performance in litres per minute. At the suction side the pump shall have a filter easily exchangeable. A thermometer shall be fixed, which indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with a tachometer indicating the speed in meter per minute. The tachometer shall be visible from the driver's seat. The function of the distributor shall be so exact that the deviation from the prescribed quantity to be spread on any square meter does not exceed 10% . The distributor shall be equipped with a device for hand spraying of the bituminous liquid, to cover any irregular area or covering the area improperly sprayed.

302.3.2 Application of Asphaltic Material

Immediately before applying prime coat, the full area of surface to be treated shall be swept with a power broom to remove all dirt and other objectionable material. If required by the Engineer, the surface shall be made moist but not saturated. Asphaltic Materials shall be applied at temperature stated in Item 301 by approved pressure distributors operated by skilled workmen. The spray nozzles and spray bars shall be adjusted and frequently checked so as to ensure uniform distribution. Spraying shall be ceased immediately upon any clogging or interference of any nozzle and remedial measures be taken before spraying is resumed.

The rate for application of asphaltic material (cut back) shall be as under:

TYPE OF SURFACE	**LITRES PER SQUARE METER**	
	Minimum	**Maximum**
1. Sub grade, Sub base, Water bound base courses, and Crushed stone base course.	0.65	1.75
2. Bridge, Wearing Surfaces, Concrete Pavement	0.15	0.4

Emulsified asphalts; SS-1, SS-1h, CSS-1h as approved by the Engineer shall be used if specified. They shall be mixed in-place with the top 50-75mm (2-3 in.) of the aggregate base. “Penetrating emulsion prime” (PEP) and “asphalt emulsion prime” (AEP) grades may be used after approval of the Engineer.

Emulsion for priming shall be diluted with water. The dilution rates shall range from 1:1 to 10:1 (water to emulsion) dependent upon the basic material characteristics and method of treatment. The application rates shall vary for a 1:1 diluted emulsion from 2.3 Lit/sq. m for high fines and tight bases to 6.8 Lit/sq. m for loose sands and very porous surfaces. In very dense surfaces it may be necessary to use higher dilution and make

multiple applications at lower rates. This is done to improve penetration and prevent runoff and pudding of the emulsion.

However, the exact rate for cut back or emulsified asphalts shall be specified by the Engineer determined from field trials.

The test methods shall be determined by the Engineer and performed by the Contractor in the presence of Engineer.

The prime coat shall be left undisturbed for a period of at least 24 hours, and shall not be opened to traffic until it has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts; any excess shall be blotted with sand or similar treatment. All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor.

The surface of structures and trees adjacent to the area being treated shall be protected in such manner so as to prevent them being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one-half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the primed area. Work shall not be started on the portion of the road not covered by previous application until the surface previously covered has dried and is ready for traffic.

302.4 MEASUREMENT AND PAYMENT

302.4.1 Measurement

The unit of measurement shall be square meter as actually covered by prime coat in accordance with these specifications. No measurement or payment will be made for the areas primed outside the limits, specified herein, shown on the plans or designated by the Engineer.

Blotting material will not be measured for payment and shall be considered subsidiary to the prime coat..

302.4.2 Payment

The payment for area primed measured as stated above, shall be made for the contract unit price per SM, which payment shall be full compensation for furnishing all labour, material, tools, equipment and incidentals and for performing all the work involved in applying prime coat, complete in place in accordance with these specifications:

Pay Item No.	Description	Unit of Measurement
302 a	Providing and applying prime coat of cut back asphalt of approved quality at the rate mentioned in Specification after brooming and cleaning of road surface.	SM

SECTION 303 BITUMINOUS TACK COAT

303.1 DESCRIPTION

The work covered by this section shall consist in furnishing all plant, labour, equipment and applying asphaltic material on a previously prepared asphaltic layer, in addition to performing all operations in connection with the application of a Bituminous tack coat, complete in accordance with these specifications and to the width shown on the typical cross- sections of applicable drawings.

303.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of item 301, "Asphaltic Materials" for emulsified asphalt, or cut back asphalt as called for in the Bill of Quantities.

303.3 CONSTRUCTION REQUIREMENTS

Immediately before applying the tack coat, all loose material, dirt or other objectionable material, shall be removed from the surface to be treated by power brooms and/or blowers, supplemented with hand brooms, as directed by the Engineer. The tack coat shall be applied only when the surface is dry, however for emulsified asphalt, application may be made on a reasonable moist surface. Application of tack coat shall be avoided in case of foggy or rainy weather. Prior to the application, an inspection of the prepared surface will be made by the Engineer to determine its fitness to receive the Bituminous binder and no tack coat will be applied until the surface has been approved.

303.3.1 Equipment

Equipment shall conform in all respect to the provision under Item 302.3.1 and shall be subject to the approval of the Engineer in addition to the maintenance of the same in a satisfactory working condition at all times. A hand power spray attachment to a bitumen pressure distributor or other container having an independently operated bitumen pump, pressure gauge, thermometer for determining the temperature of the asphalt tank contents and a hose connected to a hand power spray suitable for applying the Bituminous tack coat in the amounts specified - all to be such as to meet the approval of the Engineer, shall be furnished.

303.3.2 Application of Asphaltic Material:

Asphaltic material shall be applied by means of a pressure distributor, at the temperature stated in Item 301 for the particular material being used. Rates of application of cut back shall be within the range of **0.2-0.4 lit** / **sq. meter**.

Asphalt emulsions used for tack coats shall be diluted SS-1, SS-1h, CSS-1 and CSS-1h as specified and approved by the Engineer. The emulsion shall be diluted by adding an equal amount of water. A test dilution is recommended to be certain that the water to be used is compatible with the emulsion. To prevent premature breaking, the water always shall be added to the emulsion and not the emulsion to the water. If practical, warm water shall be preferred for dilution. The diluted material shall be applied at a rate of **0.25 to 0.70 Lit** / **sq. meter**, however; the exact rate shall be specified by the Engineer after field testing.

Care shall be taken that the application of asphaltic material is not in excess of the specified quantity; any excess asphalt shall be blotted by sand or similar treatment. All areas inaccessible to the distributor shall be treated manually using the device for hand spraying from the distributor. The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent them being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one-half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the treated area. Work shall not be started on the portion of the road not covered by previous application until the surface previously covered has dried and is ready for paving.

Traffic shall be kept off the tack coat at all times. The tack coat shall be sprayed only so far in advance of the surface course as will permit it to dry to a "tacky" condition. The Contractor shall maintain the tack coat until the next course has been placed. Any area that has become fouled, by traffic or otherwise, shall be cleaned by Contractor at his own cost before the next course is applied.

303.4 MEASUREMENT AND PAYMENT

303.4.1 Measurement

The quantities of Bituminous Tack Coat shall be measured in square meter for the actual area Tacked with asphaltic material on the prepared surface in accordance with this specification.

303.4.2 Payment

The payment of bituminous Tack coat, measured as stated above shall be paid for at the Contract unit price per square meter, which payment shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals and for performing all the work involved in applying Tack Coat complete in place, as shown on the Drawings and in accordance with these specification.

Pay Item No.	Description	Unit of Measurement
303 a	Providing and applying tack coat of cut back asphalt of approved quality at the rate mentioned in Specification after brooming and cleaning of road surface.	SM
303 b	Providing and applying tack coat of emulsified asphalt of approved quality at the rate mentioned in Specification after brooming and cleaning of road surface.	SM

SECTION 304 BITUMINOUS SURFACE TREATMENT AND SEAL COAT/ PAD COAT

304.1 DESCRIPTION

This work shall consist of one or more applications of asphaltic material and one or more covers of aggregates or an application of asphaltic material without aggregates applied in accordance with these specifications and in conformity with the lines and width shown on the typical cross-sections or as established by the Engineer.

304.2 MATERIAL REQUIREMENTS

304.2.1 Aggregate

Aggregate shall consist of clean, dry, hard, durable, tough, angular, sound crushed stone or crushed gravel of uniform quality, and free from dirt, clay and other objectionable matter. Aggregates from the sources of established adhesion properties would be used. The percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) shall not be more than forty (40). Aggregate crushing value (ACV) when tested as per BS-812 (1990) shall not exceed 25%. When subjected to five (5) cycles of sodium-sulfate soundness testing as determined by AASHTO T-104, it shall have a weight loss of not greater than ten (10) percent. The moisture content in the aggregate applied directly to the surface of the bituminous material shall not exceed three (3) percent by weight plus one-half (1/2) the water absorption of the aggregate at the time of delivery to the Project. In no case shall free moisture be drawing from the truck bed.

The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than fifteen (15) percent of particles by weight of flat or elongated, or both, that the ratio between the maximum and the minimum dimensions exceeds 2.5:1. Flakiness Index, tested under BS-812 (1990) part 105, shall be 25 (max) for nominal size 18 mm and 12 mm and 30 (max) for nominal size 9mm.

The nominal sizes of aggregates used for surface treatment; shown against table 304-4 shall be as under:

Size No. 1 – Nominal size 18 mm
Size No. 2 – Nominal size 12 mm
Size No .3 – Nominal size 9 mm
Size No. 4 – Nominal size 6 mm

The nominal sizes are defined in the table below:

Table 304-1: Definition of Nominal Sizes of Aggregate

Nominal Size (mm)	Specified Size *			
	Passing		Retained	
	Sieve (mm)	%age	Sieve (mm)	%age
18	19	100	12.5	85
12	12.5	100	9.5	85
9	9.5	100	6.3	85
6	6.3	100	4.75	85

- By convention, this item defines a fraction of material within the respective sieves.

For Material passing 3/8" Sieve, following Table shall be used:

Table 304-2: Sizes for Material Passing 3/8" Sieve

Sieve Designation		Percent Passing by Weight			
mm	Inch	Size No. 1	Size No. 2	Size No. 3	Size No. 4
9.5	3/8	0–15	0-10	–	–
4.75	No. 4	0–5	0–5	0–10	–
2.38	No. 8	–	–	0–5	0–5
1.18	No. 16	–	–	–	0–3
0.075	No. 200	0–2	0–2	0–1	0–1

304.2.2 Asphaltic Material

The asphaltic material shall conform to the requirements of Item 301 'Asphaltic Materials'. The type shall be one of the following, as shown in the Bill of Quantities or ordered by the Engineer. Spraying temperature shall be as shown against each type.

Table 304-3: Spraying Temperatures (°C) for Surface Treatments

Asphalt Type / Grade	Spraying Temperature for Surface Treatments
a. Asphalt Cements	
AC-2.5	130 min.
AC-5	140 min.
AC-10	140 min.
AC-20	145 min.
AC-40	150 min.
AR-1000	155 min.
AR-2000	140 min.
AR-4000	145 min.
AR-8000	145 min.
AR-16000	–
200-300 pen.	130 min.
120-150 pen.	130 min.
85-100 pen.	140 min.
60-70 pen.	145 min.
40-50 pen.	150 min.
b. Emulsified Asphalts	
RS-1	20-70
RS-2	50-85
HFRS-2	50-85
MS-1	20-70
MS-2	20-70
MS-2h	20-70
HFMS-1	20-70
HFMS-2	20-70
HFMS-2h	20-70
HFMS-2s	20-70
SS-1	20-70
SS-1h	20-70
CRS-1	50-85
CRS-2	50-85
CMS-2	20-70
CMS-2h	20-70
CSS-1	20-70
CSS-1h	20-70
c. Cutback Asphalts (RC, MC, SC)	
30 (MC only)	30 min.
70	50 min.
250	75 min.
800	95 min.
3000	110 min.

304.3 CONSTRUCTION REQUIREMENTS

At the time of the application, the weather shall be warm and dry, and the road surface shall be clean and dry. Spraying shall not be done unless the road temperature is above twenty (20) degree C for at least one hour prior to the commencement of spraying operations, and the temperature shall not be less than twenty (20) degree C during the spraying. Prior to applying the asphaltic material, dirt and other objectionable materials shall be removed from the surface and surface shall be primed as per item 302. If so directed by the Engineer, the surface shall be cleaned by power brooming or wire brush until all loose and foreign materials are removed.

304.3.1 Equipment

Equipment shall conform in all respects to the provisions under Item 302.3.1. The equipment shall be operated by the manpower specially trained for this work. Necessary safety arrangement for the workers, equipment and traffic shall be ensured during the operations.

304.3.2 Preparation of Surface

Irregularities and surface damage e.g. pot-holes, depressions, raveling, shall be corrected prior to surface dressing. The Engineer shall also satisfy himself that fundamental pavement defects e.g. base failure, drainage problems etc. have been remedied before surface dressing is attempted. Areas, which are excessively rich in bitumen e.g. 'bleeding', shall be cut out and patched. All patches, however, occasioned shall be thoroughly compacted, sealed and blinded with crusher dust before opening to traffic for several days before surface dressing commences.

Immediately prior to the application of binder, all dirt, dust or foreign material shall be removed by thorough brooming and / or the use of compressed air. Adhering mud or other soiling may be removed using water and brushes, the general use of water to wash the road shall not be permitted.

304.3.3 Application of Asphaltic Materials

Asphalt cement, liquid asphalt and emulsified asphalt shall be applied by means of pressure distributor manual or automatic at the temperature specified for the type and grade of asphalt being used. The rates of application shall be within the ranges given in Table 304-4. For surface treatments with Emulsified Asphalts, refer to Item 313 “Emulsified Asphalt Applications”

The spread of bituminous materials shall be at least ten (10) cm more than the width to be covered by the aggregate from the spreading device. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface. The length of spread of bituminous material shall not exceed than that which trucks loaded with cover coat material can immediately cover. Under no circumstances shall operations proceed in such manner that bituminous material will be allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

The distributor when not spreading shall be so designed that the spray bar or mechanism will not drip bituminous material on the surface of the traveled way. Distribution of the bituminous material shall be so regulated and sufficient bituminous material left in the distributor at the end of each application, so that there will be a uniform distribution of bituminous material in the spray bar. In no case shall the distributor be allowed to expel air with the bituminous material thereby causing uneven coverage. The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is ensured. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

The types of emulsion used for seal coats shall be SS-1, SS-1h, CSS-1 and CSS-1h. Coarse, angular sand shall be added to the emulsion for increased skid resistance. It shall be added at a rate of 0.5-0.8 kg/liter of emulsion. About 0.5 Lit/sq. meter shall be applied in a single application. If an additional application is desired, it shall be applied at a right angle to the first one. The seal coat must be allowed to completely cure before traffic is allowed, to prevent pickup by vehicle tires.

304.3.4 Spreading of Aggregate

Immediately after applying the asphaltic material, dry aggregate shall be uniformly and evenly distributed over the treated surface from an approved mechanical aggregate spreader or any other means approved by the Engineer. The truck carrying the aggregate shall move backward as it spreads same, so as to prevent the tyres of the truck and the mechanical aggregate spreader from driving directly on the newly sprayed asphalt. No portion of the binder shall remain uncovered for a period in excess of twenty (20) minutes after spraying.

Immediately after spreading of the aggregate, the treated surface shall be rolled with a self-propelled pneumatic-tyre roller having a minimum contact pressure of 2.8 Kg/square centimeter. A steel-wheeled roller weighing between six (6) to eight (8) tons may be used as a second roller. Rolling shall continue only until a smooth, thoroughly compacted surface is obtained. Procedures of starting, stopping, or turning of any piece of equipment which results in displacement of the cover material or damage to the seal courses be prohibited.

Any place where binder shows undulations on the surface shall be covered with additional aggregate and further rolled and broom dragged until an even surface result, and does not adhere to wheels of vehicles. Overlapping the applications of cover material shall be avoided and all spillage shall be removed from the surface.

The quantity of aggregates to be applied shall be within the ranges specified in Table 304-4. For surface treatments with Emulsified Asphalts, refer to Item 313 “Emulsified Asphalt Applications”

304.3.5 Maintenance of Traffic

Detouring of highway traffic for this work on running road will not be provided for or permitted, except when authorized by the Engineer. All construction operations shall be coordinated to result in the least practicable delay of traffic. One way traffic shall be maintained and traffic speeds restricted to fifteen (15) Km per hour. The contractor shall provide flagmen, warning signs, barricades, and a sufficient number of pilot cars to control traffic through the bituminous sealing operations when so directed by the Engineer. Pilot cars shall be used to lead the traffic through the areas of all distribution and sealing operations. Pilot cars shall be light "Pick up" trucks or other approved vehicles and shall be equipped with signs reading "PILOT CAR - DO NOT PASS" in both English and Urdu languages. Two (2) signs shall be mounted on the vehicles so as to be clearly visible from both directions. One (1) flagman shall be stationed immediately ahead of the application of the bituminous material and one (1) flagman immediately behind the section being rolled. Suitable speed limit signs shall be displayed, and the signs shall move forward with the flagman as the work progresses.

No separate payment shall be made for conformance to this paragraph. All these items being considered subsidiary to the item (s) given in the Bill of Quantities.

304.3.6 Working Period

All work shall be so conducted that the work of applying asphalt and aggregate and of all rolling shall be completed during the time from sunrise to sunset and under favorable weather conditions as determined by the Engineer.

304.3.7 Maintenance of completed work

When directed by the Engineer, the Contractor will be required to add bituminous material or aggregate or both to the portion of road identified for such purpose on the project. Furnishing additional bituminous material and furnishing, spreading, dragging and rolling of additional aggregate will not be paid for separately but will be considered as subsidiary work pertaining to the relevant item of "Bituminous Surface Treatment".

304.3.8 Opening to Traffic and after-care

There shall be no delay in opening a completed surface dressing to traffic at a controlled speed. Prior to opening to traffic any spillage of aggregates shall be removed and any binder drips or wind blown contamination shall be dusted with crusher waste. After 2-3 days under traffic, excess stone will be removed by brushing.

304.3.9 Pad Coat

To ensure chipping retention when surface dressing on a very hard surface, a pad coat consisting of application of an initial binder spray followed by 6mm. chipping will be applied. After stabilizing of pad coat under traffic, the appropriate surface dressing will be applied.

304.4 MEASUREMENT AND PAYMENT

304.4.1 Measurement

The quantity of surface treatment to be paid for shall be measured in square meter within the theoretical line in place as shown on drawing. No allowance will be given for material placed outside the theoretical limits of finished surfacing whether placed for, due to requirement of contractor's operations or placed out side the limits due to inadequate control.

304.4.2 Payment

The aggregate and asphaltic material measured as stated above shall be paid for at the contract unit price per square meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, materials, tools equipment and incidental for performing all the work in the construction of bituminous surface treatment or seal coat complete in place and according to specification, including priming of surface.

Pay Item No.	Description	Unit of Measurement
304 a	Single surface treatment with bitumen of approved quality and quantities of bitumen and aggregate as specified for each layer.	SM
304 b	Double surface treatment with bitumen of approved quality and quantities of bitumen and aggregate as specified for each layer.	SM
304 c	Triple surface treatment with bitumen of approved quality and quantities of bitumen and aggregate as specified for each layer.	SM
304 d	Seal coat/ Pad coat	SM

TABLE 304-4

Quantities of Materials for Bituminous Surface Treatments

Surface Treatment		Aggregate		Bituminous Material	
Type	Application	Size No.	Quantity Kg. /Sq. M	Quantity Litres / Sq. M	Type
Single	Single	2	12.5	1.19	(a)
				1.63	(b)
Double	First	1	24.0	1.90	(a)
				2.14	(b)
	Second	3	12.5	1.19	(a)
				1.63	(b)
Triple	First	1	24.0	1.90	(a)
				2.14	(b)
	Second	2	12.5	1.19	(a)
				1.63	(b)
	Third	3	6.5	0.68	(c)
Seal Coat / Pad Coat with Aggregate		4	4	0.5	(c)

Notes:-

i) Bituminous material types are
(a) asphalt cement only
(b) cut-back only
(c) asphalt cement or cut-back.

ii) Quantities of bituminous material may be varied by the Engineer by $\pm$ 15% depending on site conditions.

iii) Prime coat shall be applied prior to the surface treatment for the newly constructed pavement at the rate as specified in the item 302.3.2.

SECTION 305 ASPHALT CONCRETE WEARING COURSE - PLANT MIX

305.1 DESCRIPTION

This work shall consist of furnishing aggregates and asphalt binder at a central mixing plant, to a specified mixing temperature, transporting, spreading and compacting the mixture in an approved manner on primed or tacked base, sub base, sub grade, bridge deck or concrete pavement in accordance with these specifications and in conformity with the lines, grades and typical cross-sections shown in the drawings or as directed by the Engineer.

305.2 MATERIAL REQUIREMENTS

305.2.1 Mineral Aggregates

The Aggregates shall consist of coarse aggregates, fine aggregates and filler material, if required and shall be clean, hard, tough, durable and sound particles of uniform quality, geology, petrology and free from decomposed material, vegetable matter, soil, clay, lumps and other deleterious substances.

Coarse aggregate which is the material retained on an AASHTO No. 4 Sieve, shall consist of one hundred (100) % crushed rock or crushed gravel having two (2) faces mechanically crushed. The type of source shall be uniform throughout the quarry location from where such a material is obtained. The coarse aggregates shall be free from an excess of flat or/and elongated particles.

Fine aggregate which is the material passing from AASHTO No. 4 sieve, shall consist of 100% crushed material from rock or boulder. Fine aggregate shall be stored separately, and no natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing the AASHTO No. 200 sieve, mineral filler material shall be added as approved by the Engineer. The filler shall consist of finely divided mineral matter such as rock dust, hydrated lime, hydraulic, calcined dust cement or other suitable mineral matter free from lumps, balls or other deleterious material and shall conform to the following gradation:

Table 305-1: Required Gradation for Mineral Aggregate

Sieve Designation		Percent Passing by Weight
mm	Inch	
0.600	No. 30	100
0.300	No. 50	95-100
0.075	No. 200	70-100

The coarse and fine aggregates shall meet the following requirements:

a) The percent of wear by the Los Angeles Abrasion test (AASHTO T 96) shall not be more than thirty (30).

b) The loss when subjected to five cycles of the Sodium Sulphate Soundness test (AASHTO T 104) shall be less than twelve (12) percent.

c) The Sand Equivalent (AASHTO T 176) determined after all processing except for addition of asphalt cement shall not be less than 45.

d) All aggregates shall have a liquid limit of not more than twenty five (25) percent and a Plasticity Index of not more than four (4) as determined by AASHTO T-89 and T-90.

e) The portion of aggregates retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 10 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimension = 2.5:1).

f) Stripping test shall be performed on crush aggregates as described under AASHTO-182 and only that material shall be allowed which qualifies the test.

g) The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behaviour so that their affinity with the bitumen to be used is verified.

h) Petrographic examination of the coarse aggregate shall be conducted if so directed by the Engineer.

The percentage of particles having certain proportions between their largest and smallest dimensions (i.e. between the largest distance the particles can fill out between two parallel planes that will permit the particle to pass), shall be determined in the following way:

i. Form a sample of coarse aggregates so that all particles passing No. 4 sieve are eliminated. The sample shall be of sufficient quantity so that at least 100 particles remain.

ii. By means of a sliding caliper, the largest and smallest dimensions, as defined above, are determined for each particle and its proportion calculated (with one decimal).

iii. The total weights of particles having the proportions two and a half (2.5) or less and three (3) or less, are determined and their percentage in relation to the total sample are calculated.

305.2.2 Asphaltic Material

Asphaltic binder to be mixed with the aggregate to produce asphaltic wearing course shall be asphalt cement penetration grade 40-50, 60-70 or 80-100 as specified by the Engineer. Generally it will meet the requirement of AASHTO M-20.

305.2.3 Asphalt Concrete Wearing Course Mixture

The composition of the asphaltic concrete paving mixture for wearing course shall conform to Class A and/or Class B shown in the following table:

Table 305-2

Asphalt Concrete Wearing Course Requirements

Mix Designation		**Class A**	**Class B**
Compacted Thickness		**50-80 mm**	**35-60 mm**
Combined Aggregate Grading Requirements			
Sieve Designation		**Percent Passing by Weight**	
mm	**Inch**		
25	1	100	–
19	3/4	90-100	100
12.5	1/2	-	75-90
9.5	3/8	56-70	60-80
4.75	No. 4	35-50	40-60
2.38	No. 8	23-35	20-40
1.18	No. 16	5-12	5-15
0.075	No. 200	2-8	3-8
Asphalt Content by weight Percent of total mix		3.5 (Min.)	3.5 (Min.)

The asphalt concrete wearing course mixture shall meet the following Marshal Test Criteria:

Compaction, number of blows at each end of specimen	75
Stability	1000 Kg (Min)
Flow, 0.25 mm (0.01 inch)	8-14
Percent air voids in mix	4-7
Percent voids in mineral aggregates	According to table 5.3 MS-2 (Asphalt Institute - USA), sixth edition, 1993.
Loss of Stability	20% (Max.)

305.2.4 Job-Mix Formula

At least one week prior to production, a Job-Mix Formula (JMF) for the asphaltic wearing course mixture or mixtures to be used for the project, shall be established jointly by the Engineer and the Contractor.

The JMF shall be established by Marshall Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993 or the latest Edition.

The JMF, with the allowable tolerances, shall be within the master range specified in Table 305-2. Each JMF shall indicate a single percentage of aggregate passing each required sieve and a single percentage of bitumen to be added to the aggregates.

The ratio of weight of filler (Passing No. 200) to that of asphalt shall range between 1 – 1.5 for hot climate areas with maximum ambient temperature more than 40 ^{o}C.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto with the following ranges of tolerances, however, due to this variation in percentage of materials no individual sieve component shall fall outside the envelope given in Table 305-2 for applicable class of combined gradation.

Combined aggregates gradation

Retained No. 4 and larger	± 7.0%
Passing No. 4 to No. 100 sieves	± 4.0%
Passing No. 200	± 1.0%

Asphalt Content.

Weight percent of total mix	± 0.3%

In addition to meeting the requirements specified in the preceding items, the mixture as established by the JMF shall also satisfy the following physical property:

Loss of Marshall Stability by immersion of specimen in water at sixty (60) degree C. for twenty four (24) hours as compared with the stability measured after immersion in water at sixty (60) degree C. for twenty (20) minutes shall not exceed twenty (20) percent. If the mixture fails to meet this criterion, the JMF shall be modified or an anti-stripping agent shall be used.

Should a change of sources of materials be made a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new Job Mix Formula will be required.

305.3 CONSTRUCTION REQUIREMENTS

Construction requirements for this Item shall conform with the same as specified for Asphaltic Concrete Base Course Plant Mix under Item 203.3, except as modified in the following sub-items.

305.3.1 Preparation of Base Course Surface

Before spreading materials, the surface of the previously constructed and accepted base course on which the mix is to be placed shall be conditioned by application of a tack coat, if directed by the Engineer.

305.3.2 Pavement Thickness and Tolerances

The asphalt concrete wearing course shall be compacted to the desired level and cross slope as shown on the drawing or as directed by the Engineer.

The tolerances in compacted thickness of the wearing course shall be ±3mm from the desired thickness shown on the drawings. For determination of thickness one (1) core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than three (3) mm, but not more than ten (10) mm, payment will be made at an adjusted price as specified in table 305-3, clause 305.4.2.(2) of this specification.

The surface of the wearing course shall be tested by the Engineer using a 5 meters straightedge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point exceed five (5) millimeters. The cross fall (camber) shall be with ± 0.2 percent of that specified, and the level at any point shall be within ± three (3) mm of the level shown on the Drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer.

305.3.3 Acceptance Sampling and Testing

Acceptance of sampling and testing for this Item with respect to materials and construction requirements, not specified herein, shall be in accordance with the relevant, "Tables for Sampling and Testing Frequency" in these specifications.

305.4 MEASUREMENT AND PAYMENT

305.4.1 Measurement

The quantities of Asphaltic wearing course shall be measured by volume in CM. laid and compacted in place. Measurements shall be based on the dimension as shown on plans or as otherwise directed or authorized by the Engineer. A tolerance of ± three (3) mm shall be allowed in compacted thickness of wearing course. However, any asphalt in excess of 3 mm shall not be paid and any layer deficient by more than 3 mm but not exceeding 10 mm shall be paid as per clause 305.4.2 (2) of this specification.

The quantity of bitumen material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of Bitumen or asphaltic concrete wasted or remaining on hand after completion of the work shall not be measured or paid for.

305.4.2 Payment

1) The quantity determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item. Asphalt additive or anti stripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items of Asphaltic wearing course.

2) **Price adjustment.** If the thickness determined as per clause 305.3.2 of this specification is deficient by more than three (3) mm, but not more than ten (10) mm, payment will be made at an adjusted price as specified in table 305-3 below:

Table 305-3: Price Adjustment

Deficiency in thickness as determined by cores	Proportional Rate of contract Price allowed.
0.0 mm to 3.0 mm	100%
3.1 mm to 5.0 mm	90%
5.1 mm to 10.0 mm	80%

When wearing course is more than ten (10) mm deficient in thickness, the contractor shall remove such deficient areas and replace them with wearing course of an approved quality and thickness or the contractor may opt to place an additional layer of wearing course asphalt, grading with a minimum thickness of 35 mm. The contractor will receive no compensation for the above additional work.

Alternately, the Contractor may choose to overlay the area in a thickness of 30 mm (min.) with smooth transition as approved by the Engineer on either side with no extra compensation.

Pay Item No.	Description	Unit of Measurement
305 a	Asphaltic concrete for wearing course (class A) with layer of thickness between 50-80mm (Plant mix).	CM
305 b	Asphaltic concrete for wearing course (class B) with layer of thickness between 35-60mm (Plant mix).	CM

SECTION 306 SHOULDER TREATMENT

306.1 DESCRIPTION

This work shall consist of constructing shoulders of the types specified hereinafter in accordance with the specifications and in conformity to the lines, grades thickness and typical cross-sections shown on the plans or established by the Engineer.

306.1.1 Definition of Shoulders

That portion of the completed road construction which lies above the elevation of the subgrade or sub-base and which extends from the edge of the wearing course to the point of inter-section with the embankment slopes on either side of the road centerline.

306.2 MATERIAL REQUIREMENTS

306.2.1 Earth Shoulders

The material used for "Earth Shoulders" shall consist of suitable materials from roadway or structural excavation supplemented by additional suitable material from borrows excavation or as designated on the plans and shall be obtained from sources approved by the Engineer.

306.2.2 Aggregate Shoulders

Material used for "Aggregate Shoulders" shall be of class designated on the plans and shall conform to all the requirements of item 201, "Granular Sub base", item 202, "Aggregate Base Course" or item 206, "Water Bound Macadam Base".

306.2.3 Soil Cement Stabilized Shoulders

Material for soil cement shoulders shall conform to all the requirements of item 204, "Soil Cement Stabilized Sub base or Base".

306.2.4 Asphaltic Materials

Materials for surface treatment of shoulders shall be liquid asphalts, emulsified asphalts or asphalt cement as specified or shown on the drawings and in the Bill of Quantities. Asphaltic materials shall conform to all the requirements of item 301 for the type specified.

06.3 CONSTRUCTION REQUIREMENTS

306.3.1 General

All shoulders shall be formed and compacted as soon as practicable after the asphalt paving on the traffic lanes is completed, however in the case of cement concrete surfacing, shouldering operation shall not be initiated prior to Engineer's approval.

306.3.2 Shouldering and delineation

On projects that carry traffic through construction, the contractor shall begin shouldering on the second day of the laying of the final roadway surfacing layer, unless weather conditions prevent this operation, in which case the shouldering shall begin as soon as the weather does permit. If the contractor fails to begin the shouldering within a reasonable time after the last layer has been laid, whether the project has a flow of traffic through construction or not, the Engineer may order the contractor to cease paving until the shoulder work has begun. The shouldering shall be a continuous

operation from that time until completion, with the weather being the only delaying factor. The Contractor shall, on roads under traffic or as directed by the Engineer, delineate the edge of pavement as soon as the surfacing is begun and maintain the delineation until the shoulders are completed. The delineators shall be approved prior to use and shall be placed at the edge of the surfacing at approximately one hundred (100) meter intervals. The cost of this delineation will be considered subsidiary to other items in the Bill of Quantities and will not be paid for directly.

306.3.3 Earth Shoulders

Earth shoulders shall be constructed in accordance with the applicable paragraphs under Item 108.

306.3.4 Aggregate Shoulders

Aggregate shoulders shall be constructed in accordance with the requirements of Item 201, 202 or 206 whichever is shown on the drawings.

306.3.5 Soil Cement Stabilized Shoulders

Soil cement stabilized shoulders shall be constructed in accordance with the requirements of item 204.

306.3.6 Asphaltic Treatment of Shoulders

The asphaltic treatment of the prepared shoulders shall be either a bituminous surface treatment or seal coat or a layer of asphaltic concrete as shown on the plans or in the Bill of Quantities. Detailed construction procedures for the particular treatment specified are outlined under item 203, 304, or 305.

306.4 MEASUREMENT AND PAYMENT

The quantities for shoulder materials and treatment shall be measured and paid for as specified under the particular pay items in the work listed below.

The quantities of different items of work as mentioned below shall be added to relative items of the bill of quantities.

Pay Item No.	Description	Unit of Measurement
306 a	Formation of Embankment from Roadway Excavation in Common Material	CM
306 b	Formation of Embankment from Borrow Excavation in Common Material	CM
306 c	Formation of Embankment from structural Excavation in Common Material.	CM
306 d	Granular Sub Base.	CM
306 e	Aggregate Base.	CM
306 f	Asphaltic Base - Plant Mix. Class.....	CM

306 g	Cement Stabilized Sub base	CM
306 h	Cement Stabilized Base	CM
306 i	Cement content	Ton
306 j	Liquid Asphalt for curing seal, type ___	Ton
306 k	Emulsified Asphalt for curing seal, type ___	Ton
306 l	Water bound Macadam Base.	CM
306 m	Bituminous Surface Treatment and Seal Coat.	SM
306 n	Asphalt Concrete Wearing Course Plant Mix. Class.....	CM

SECTION 307 B I T - M A C

307.1 DESCRIPTION

This item shall consist of furnishing and mixing aggregates with asphalt binder at site in mobile mixing plant, spreading, compacting on an approved primed sub grade, sub base or base course, for potholes repair, leveling course and wearing course in accordance with the specification and in conformity with the lines, grade, thickness and typical cross-section shown on the Drawings or as directed by the Engineer including sealing of cold bituminous surface cracks with sand-bitumen slurry.

307.2 MATERIAL REQUIREMENTS

307.2.1 Mineral Aggregate

Mineral aggregates for BIT-MAC Construction shall consist of coarse aggregates, fine aggregate and filler material, all conforming to the following specification requirements:-

a. Coarse aggregate which is the material retained on No. 4 Sieve and Passing 25.4 mm sieve, shall consist of crushed rock crushed boulder, or crushed gravel. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shales, clay lumps or other deleterious substances. Rock or boulders from which coarse aggregates shall be obtained, must be of uniform quality throughout the quarry location.

b. Fine aggregates which is the material passing No. 4 sieve shall consist of crushed sand.

c. When combined gradation of coarse and fine aggregates is deficient in material passing No. 200 sieve, mineral filler shall be added. The filler material shall consist of finely divided rock dust from sound rock, hydrated lime or hydraulic cement. At the time of use it shall be sufficiently dry to flow freely, free from lumps.

Aggregate should be stored on hard clean surface so as to facilitate prompt inspection and control. Private property shall not be used for storage purposes without written consent of the owner or lessee and payment to him by contractor, if necessary. Material shall be stored in such a way as to prevent segregation and coning to ensure proper control of gradation. The equipment and methods used for stockpiling and removing aggregates shall be such that no degradation of aggregate will result and no appreciable amount of foreign material will be incorporated into the aggregate. When aggregates containing a wide range of sizes are to be incorporated, they must be stockpiled separately to prevent intermingling. Mineral Filler must be protected from moisture to eliminate caking and hardening.

307.2.2 Bituminous Binder

Asphaltic binder used shall conform to standard specification of petroleum asphalt having grades 60-70 or 80-100 penetration. Generally it will meet the requirement of AASHTO M-20, Table 301-2.

307.2.3 DESIGN CHARACTERISTICS

Optimum Grading Curves for different types of hot mix asphaltic design related to quantum of repair work and maximum size of aggregates, given in Table 307-1, must be carefully selected considering average thickness of patches.

Design sheet under table 307-1 showing Dense Graded Mix used for leveling courses and potholes should use little asphalt content of such quantity to prevent bleeding through subsequent wearing course or surface treatment. Design sheet under table 307-2. is suitable for open graded wearing course having rough surface texture with good skid resistance thus having minimum bleeding tendency.

307.3 CONSTRUCTION REQUIREMENTS

307.3.1 Mixing Requirement

Asphalt cement shall be heated to a max. temperature of 163 degrees centigrade at the time of mixing. Asphalt cement heated above 163 degrees centigrade shall be rejected. Temperature of asphalt shall be checked frequently. Each aggregate ingredient shall be heated to temperature 150-160 degrees centigrade for at least six (6) minutes before mixing of asphalt cement to ensure complete drying of aggregates. The range of heating of aggregates shall be strictly followed, to ensure proper coating of aggregates. Fine aggregates shall be introduced into the dryer (mixer) first followed by the coarse aggregates to assure proper mixing. Quantity of aggregates fed to dryer (mixer) must be accurately controlled by suitable measuring device (Iron box) having predetermined volume of one (1) cubic foot or as instructed by Engineer.

Both bitumen and aggregates must be heated before they are combined in the mixer drum. Mixing temperature should be kept within the range of 140-170 degrees centigrade.

To achieve uniform mixing and proper coating, aggregates and asphalt cement must be thoroughly mixed for a minimum duration of ninety (90) seconds. Mixing time shall be prolonged to hundred (100) seconds if coating of aggregates is not proper. After one hundred and twenty (120) seconds if it is still not possible to get good coating, the aggregate drying time must be increased.

TABLE 307-1

DESIGN SHEETS FOR DENSE GRADED HOT MIX. FOR LEVELING AND POTHOLES, RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE.

AGGREGATE IN MIX	FILLER	FINE AGG.	COARSE AGGREGATES					BITUMEN USED.	REMARKS
Sieve Size Inch (mm)	**200 (0.075)**	**No. 8 (2.36)**	**No. 4 (4.75)**	**3/8" (9.5)**	**1/2" (12.5)**	**3/4" (19)**	**1" (25)**	4% by Wt. of Mix.	Minimum Layer Thickness:-20 mm Aggr. max size : 9 mm Rate of Aggr. Appl. :-50 Kg/SM
Specification Range	4-12	43-56	55-75	90-100					
Allowed % Passing	9	48	65	100					
% by Weight	57%		43%						
Qty. by Proportion.	4		3						
Specification Range	3-11	30-45	46-60	72-87	87-100			4% by Wt of Mix.	Minimum Layer Thickness: 30mm Aggregate Size:- 12mm Rate of Aggr. Appl.:- 70Kg/SM.
Allowed % Passing	8	36	54	80	100				
% by Weight	46%		54%						
Qty. by Proportion.	3		4						
Specification Range	4-11	32-46	46-60	65-80	75-88	90-100		3.5% by Wt. of Mix.	Minimum Layer Thickness:- 50mm Aggr.size:- 20mm Down Rate of Aggr. Appl.: 115 Kg/SM.
Allowed % Passing	8	38	53	73	82	100			
% by Weight	46%		54%						
Qty. by Proportion.	3		4						
Specification Range	4-12	24-37	34-47	49-61	57-70	70-87	88-100	3.5% by Wt. of Mix.	Minimum Layer Thickness:-50mm Aggr. size:- 20mm Down Rate of Aggr. Appl.: 150 Kg/SM.
Allowed % Passing	8	30	40	54	62	76	100		
% by Weight	46%		54%						
Qty. by Proportion.	3		4						

TABLE 307-2

DESIGN SHEETS FOR OPEN GRADED HOT MIX. FOR WEARING COURSE AND RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE.

AGGREGATE IN MIX	FILLER	FINE AGG.	COARSE AGGREGATES					BITUMEN USED.	REMARKS
Sieve Size Inch (mm)	**200 (0.075)**	**No. 8 (2.36)**	**No. 4 (4.75)**	**3/8" (9.5)**	**1/2" (12.5)**	**3/4" (19)**	**1" (25)**	4% by Wt. of Mix.	Minimum Layer Thickness: 20mm Aggregate Max. Size-9 mm Rate of Aggr. Appl.: 50 Kg/SM.
Specification Range	2-10	24-37	40-50	88-100					
Allowed % Passing	6	30	43	100					
% by Weight	36%		64%						
Qty. by Proportion.	1		2						
Specification Range	1-9	14-28	32-45	57-70	75-100			3.5% by Wt. of Mix.	Minimum Layer Thickness:- 30mm Aggregate Size:-12mm Rate of Aggr. Appl.: 70Kg/SM.
Allowed % Passing	6	25	37	63	100				
% by Weight	31%		69%						
Qty. by Proportion.	1		2						
Specification Range	1-10	14-28	25-40	45-57	58-70	87-100		3.5% by Wt. of Mix.	Minimum Layer Thickness:- 50mm Aggr. size 20mm Down Rate of Aggr. Appl.: 110 Kg/SM.
Allowed % Passing	6	20	32	50	65	100			
% by Weight	26%		74%						
Qty. by Proportion.	1		3						
Specification Range	2-10	12-25	20-35	36-51	45-60	65-81	82-100	3.5% by Wt. of Mix.	Minimum Layer Thickness:- 60mm Aggr. size - 25mm Down Rate of Aggr. Appl.:-135 Kg/SM.
Allowed % Passing	6	17	26	41	52	72	100		
% by Weight	23%		77%						
Qty. by Proportion.	1		3						

307.3.2 Deep Patches/Pot holes

The surfaces of base course thus prepared as mentioned under Item 207, shall be primed to receive Bit Mac in a thickness as per drawings or as directed by the Engineer, Bit Mac shall be spread carefully to avoid segregation. Compaction shall be done with equipment suited to the size of job. A vibratory plate compactor is recommended for small patches. Whereas roller may be more practical for larger areas. Straight edge or stringline shall be used to check riding quality and the alignment of the patch.

307.3.3 Leveling Course

All local depressions corrugated surface, ripples across the pavement should be rectified before leveling course is placed. Clean the area free of dust or other loose material with mechanical broom or compressed air. Apply light tack coat, 0.2 to 0.7 litres per square meter of A.C 80/100 penetration grade. After drying dense graded hot Bit-Mac shall be spread in layer not more than seven (7) centimeters in thickness. Spread shall be done carefully to prevent segregation and compact with steel wheeled and pneumatic tyred roller. For small pot holes hand tempers shall be allowed. Use stringline to check the riding quality of the leveling course.

307.3.4 Wearing Surface

307.3.4.1 Mini Mixing Plant

Local made bitumen aggregate mixer equipment used for preparation of Bit-Mac shall be in good working condition, of sufficient capacity, capable of being operated to produce a uniform blend with the given ingredients.

307.3.4.2 Preparation of aggregates

Aggregates shall be stored and handled as discussed under item 307.2, Material Requirement.

307.3.4.3 Hauling Equipment

Bit-Mac mixed material shall be delivered in tight, clean and smooth metal bed hand trolleys, or any method as convenient to the Contractor and approved by the Engineer.

307.3.4.4 Preparation of Base or Existing Pavement Surface

Surface of base or existing pavement upon which Bit-Mac mix is to be placed shall be cleaned by means of compressed air to remove dust or as approved by the Engineer.

Priming shall be done in a manner as described in item 302. The rate of application of prime coat shall be 0.8-1.5 litres per square meter. Tack coat shall be done in a manner as described in item 303. The rate of application of tack coat shall be 0.2-0.4 litres per square meter. When surface of existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by leveling course as described above.

Sand bitumen slurry to seal the cracks in clod bituminous surface shall be injected by pressure pumps with nozzles filled at the end instead of spray pipe in conventional harris trolley.

307.3.4.5 Spreading and Finishing

Bit-Mac mixture shall be placed on approved surface, struck off to required section manually with rakes or hand tools by experienced foreman, distributed over the entire width or partial width as required. All mixtures shall be spread at temperatures not less than one hundred and forty (140) degrees centigrade. Mixture shall not be placed on any wet surface or when the atmospheric temperature is below five (5) degree centigrade or when the weather is foggy or rainy.

307.3.4.6 Compaction

Roller shall be steel wheel or pneumatic tyred. The roller (s) shall be in good working condition, capable of reversing without backlash, capable to be operated at speeds slow enough to avoid displacement of Bit-Mac. The number and weight of rollers shall be sufficient to compact the mixture while it is still in workable condition to obtain compaction to Engineer's satisfaction. The use of equipment which results in excessive crushing of aggregates shall not be permitted.

After spreading and strike off as soon as the mix condition permit the rolling to be performed without excessive shoving or tearing, the Bit-Mac mixture shall be thoroughly and uniformly compacted. Rolling will not be prolonged to avoid appearance of cracks. Rolling will be done longitudinally, beginning at the lower side of the spread and proceeding towards the higher side, overlapping successive trips by at least one half (1/2) the width of rear wheels of roller.

Roller shall be operated at speed slow enough to avoid displacement of mixture. To prevent adhesion of mixture to rollers, the wheels of rollers shall be kept properly moist with water, but avoiding excess water. Rolling shall be continued until all roller marks have been eliminated.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or mechanical tampers.

Any mixture that has become cold enough, mixed with dirt or is defective in any way shall be replaced with fresh hot mixture and compacted to conform the requirement.

307.4 MEASUREMENT AND PAYMENT

307.4.1 Measurement

Unless otherwise shown on the plans or as directed by the Engineer, quantity of BIT-MAC shall be measured by theoretical volume of compacted mix, in place, in cubic meters. Measurement will be based on the dimensions as shown on plans or as directed by the Engineer. No measurement will be made for unauthorized areas or for extra thickness than specified. Minimum quantity for pot hole shall be 0.05 cubic meters.

307.4.2 Payment

The accepted quantities measured above shall be paid for at the contract unit price per cubic meters of BIT-MAC for the Pay Item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for slurry seal, priming and tack coat, furnishing all materials, hauling, placing, rolling, labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
307 a	Dense graded hot Bit-Mac with asphalt and aggregate quantity/quality as mentioned in Specification and thickness as specified.	CM
307 b	Open graded hot Bit-Mac with asphalt and aggregate quantity/quality as mentioned in Specification and thickness as specified.	CM

SECTION 308 PAVEMENT RECYCLING

308.1 DESCRIPTION

Pavement Recycling shall consist of one of the following options as specified:
(1) Hot Mix Recycling ……. Item 308.2
(2) Hot In-Place Recycling (HIR) ..... Item 308.3
(3) Cold In-Place Recycling (CIR) ..... Item 308.4
(4) Full Depth Reclamation (FDR) ..... Item 308.5

General guidance for selection of Pavement Recycling option is provided in the Table 308-1.

308.2 HOT-MIX RECYCLING

308.2.1 DESCRIPTION

This shall consist of heating and removal of the existing asphalt concrete layer to a designated depth, adding a calculated quantity of asphalt binder, adding of freshly prepared asphalt concrete of specified quality, mixing, laying and compaction of properly mixed asphalt concrete in thickness and width as per drawings or as directed by the Engineer.

308.2.2 MATERIAL REQUIREMENTS

308.2.2.1 Asphaltic Material

Material specifications for asphalt binder shall correspond to the specification requirements elaborated under item 301.

308.2.2.2 Aggregate

Material specifications for aggregate material shall be in accordance to the specification requirements explained under items 203 or 305 for Asphaltic Base Course and Asphaltic Wearing Course, as applicable.

308.2.2.3 Asphalt-Recycling Agent

Asphalt recycling agent shall be a homogeneous hydrocarbon product with free flowing properties at pumping temperature and having physical characteristics so as to restore aged asphalt binder to requirements of current asphalt binder specifications. It shall conform to the requirements of ASTM D-4552. Recycling agent in Emulsion form shall conform to ASTM D-5505 and shall be used only after written approved of the Engineer.

The choice of RA grade shall depend on the amount and hardness of the asphalt in the aged pavement. Lower viscosity RA types shall be used to restore aged asphalts of high viscosity and vice versa. Additionally, grades RA 1, RA 5, RA 25, and RA 75 shall be used for hot-mix recycling of salvaged asphalt concrete when no more than 30% virgin aggregate is added, while grades RA 250 and RA 500 shall be used when more than 30% virgin aggregate is incorporated into the mix.

The final selection of recycling agent shall be done as per Job Mix Formula.

Table 308-1: Guide for Selection of Recycling Method (1)

Type of Pavement Distress	Hot Mix Recycling	Hot In-Place Recycling	Cold In-Place Recycling	Full Depth Reclamation
Surface Defects				
Raveling	o	o[2]		
Bleeding (flushing)	o	o[5]		
Slipperiness	o	o[2]		
Deformation				
Corrugations (wash-boarding)	o	o[5]		
Rutting – shallow[3]	o	o[5]		
Rutting – deep[4]	o		o[6]	o[6,7]
Cracking / Load Associated				
Alligator	o		o	o
Longitudinal - wheel path	o	o[8]	o	o
Pavement edge	o		o	o
Slippage	o	o[9]		
Cracking / Non-Load Associated				
Block (shrinkage)	o		o	o
Longitudinal-joint	o	o[10]		
Transverse (thermal)	o		o	o
Reflection	o		o	o
Maintenance Patching				
Spray	o[11]		o[11]	o
Skin	o[11]		o[11]	o
Pothole	o		o	o
Deep (hot mix)	o		o	o
Problem in Base / Sub-grade (Soft, Wet)				o
Ride Quality / Roughness				
General unevenness	o	o		
Depressions (settlement)	o[12]	o[12]		o[13]
High spots (heaving)	o[12]	o[12]		o[14]

1 Final selection of recycling method is to be made after detailed pavement distress study.
2 Applicable if the surface course thickness does not exceed 1.5".
3 Rutting is limited to the upper portion of the pavement structure (top 1.5 - 2").
4 Rutting is originating from the lower portion of the pavement (below surface course and includes base and sub-grade).
5 May be a temporary correction if entire layer affected not removed or treated by the addition of special asphalt mixtures.
6 The addition of new aggregate may be required for unstable mixes.
7 The chemical stabilization of the sub-grade may be required if the soil is soft, wet.
8 Applicable if the cracking is limited to the surface course of the pavement.
9 Applicable if the treatment is to a depth below the layer where the slippage is occurring.
10 Applicable if the cracking is limited to the surface course of the pavement.
11 In some instances, spray and skin patches may be removed by cold planning prior to these treatments (considered if very asphalt rich, bleeding).
12 May be only a temporary correction if the distress related to a sub-grade problem.
13 Used if depressions due to a soft, wet sub-grade condition.
14 Used if the high spots caused by frost heave or swelling of an expansive sub-grade soil.

308.2.3 CONSTRUCTION REQUIREMENTS

All relevant construction requirements of Item 203 or 305 shall be applicable for Hot Mix Recycled Asphalt treatment as per type of layer (Base or Wearing course). Additionally, following considerations shall also be applicable:

1. The exact locations of the areas to be recycled along with the respective thicknesses thereof shall be determined and delineated by the Engineer immediately prior to the start of the Work.
2. Surface to be recycled shall be cleaned from untreated base soils and other deleterious materials.
3. The existing asphaltic pavement layer shall be removed in such a manner as to prevent the mixing of the asphalt-bound materials with soils and other deleterious materials, or damage the remaining pavement course or sub layers (base, sub base, or sub grade). The surface shall be smooth conforming to the required levels and slopes.
4. The surface shall be thoroughly checked before placing the asphaltic concrete. If the Contractor finds any defect on the surface or in the sub layers, he shall inform the Engineer, in writing, detailing the extent of the problem, its possible causes, and the remedy method. Defect found due to the Contractor's removal operations, as determined by the Engineer, shall be repaired by the Contractor at his own expense and prior to the placement of the recycled layer. Deficient parts of base course or sub-grade that are to be restored, as shown on the plans or directed by the Engineer prior to start of the removal operations, shall be repaired and paid for separately as specified in the pertinent sections of the Contract documents and Bill of Quantities.
5. Reclaimed Asphalt Pavement (RAP) materials shall be reduced, without grinding the aggregates, to a size smaller than thirty seven and one half (37.5) millimeters as specified in Table 308-2

Table 308-2: Gradation requirement of aggregate in RAP

Sieve Size	Percent Passing
37.5 mm (1.5 inch)	100
25 mm (1 inch)	90-100

6. RAP materials shall not be exposed to flame for heating or mixing purpose at any time.
7. Reclaimed aggregate, after being reduced to the required size and prior to their use in the recycled mixture, shall be segregated into two sizes: course; retained on No. 4 sieve (4.75 millimeter), and fine; passing No. 4 sieve (4.75 mm), when using central plant mixing. Special care shall be taken to avoid loss or contamination of fines.
8. The used mixing plant shall be suitable to feed all mix components at their proportions in the JMF, and heating the RAP to the required temperature by heat transfer with the added aggregates so as not to damage the asphalt binder, and be capable to produce uniform asphaltic concrete conforming to the specifications.
9. When Central Plant Mixing is used, the required fresh aggregate temperatures with respect to various ratios of RAP and fresh aggregates, moisture content and final mix discharge temperatures shall be as listed in the table 308-3

Table 308-3: Required Aggregate Temperatures for Central Plant

A. RATIO. 10% RAP / 90% Aggregate				
Reclaimed Material Moisture Content, %	Recycled Mix Discharge Temperature			
	104°C	116 °C	127 °C	138 °C
0	121	138	152	163
1	127	143	154	168
2	132	146	157	171
3	138	149	163	174
4	141	152	166	177
5	143	157	168	182
B. RATIO. 20% RAP / 80% Aggregate				
0	138	154	168	182
1	146	160	177	191
2	154	168	182	196
3	163	177	191	204
4	171	185	199	213
5	179	193	207	221
C. RATIO. 30% RAP / 70% Aggregate				
0	157	174	191	207
1	168	185	202	218
2	182	199	216	232
3	196	213	229	246
4	210	227	243	260
5	224	241	257	274
D. RATIO. 40% RAP / 60% Aggregate				
0	179	199	218	238
1	199	218	238	257
2	218	238	257	277
3	243	260	279	299
4	260	279	299	321
5	285	302	321	341
E. RATIO. 50% RAP / 50% Aggregate				
0	210	235	257	282
1	241	268	288	310
2	271	293	318	342
3	302	327	349	374
4	338	360	379	404
5	366	391	413	438

Note: 11°C loss between dryer and pugmill assumed in these values.

308.2.3.1 Equipments

The Contractor shall furnish suitable equipment to execute the recycling work. The number and the production capacity of this equipment shall be within the Contract time in accordance with his Program of Work as approved by the Engineer. This equipment in additions to that required as per Items 203 and 305 shall be, but not limited to, the following:

308.2.3.1.1 Cold Milling Machine

The cold milling machine shall be self-propelled, equipped with a rotating cutting cylinder and replaceable cutting teeth and be of such size and capacity as may be required to perform the milling work in accordance with required depth. The machine should be able to provide a uniform profile and cross slope, and capable of accurately

and automatically establishing profile grades within ± 2 mm along each edge of the machine by referencing from the existing pavement by means of a ski or matching shoe, or from an independent grade line. The machine shall have a water tank, pump and spray bar for applying cooling water to the teeth during cutting and for control of dust. The cold milling machine shall be equipped with an electronically controlled leveling device which will produce the grade and cross-slope specified, and it shall be able to ride-over obstacles such as manhole covers.

308.2.3.1.2 Crushers

Big lumps of RAP shall be crushed, using special crushers to obtain the required gradation. Care shall be taken not to remove fines from the RAP. The crusher shall not produce additional fines or new fractured faces in the RAP.

308.2.3.1.3 Mixing Plants

The plants shall be equipped with devices to raise the RAP temperature by induction with the added aggregates without contacting the flame. These plants may be a batch plant, continuous mix pugmill, or dryer-drum mixing plant. Plants shall be equipped with controls to feed the RAP to pugmill or drum directly within the allowable limits.

Central Batching Plant

Plants used for the preparation of bituminous mixtures shall be "Batching Plants" conforming to AASHTO M-156, and of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. The batching plant shall be modified to allow heating of RAP with fresh aggregates without emission of excessive smoke or other harmful effluents.

Drum Mixing Plant

When the recycling construction with drum mixing is selected, the drum mixer plant shall be one of the following:

i. Central Entry Type
ii. Parallel Flow Drum Mixer with counter flow RAP
iii. Counter Flow Drum Mixer
iv. Double/Triple Barrel Counter Flow Drum Mixer

Any other type of drum mixing plant may be approved by the Engineer provided that during its operation fresh asphalt, RAP material or recycling agent shall not come in direct contact with the flame, and it shall not give off excessive smoke and cause damage to the environment.

308.2.3.2 Construction Procedure

The construction procedure shall include, but shall not be limited, to the following:

308.2.3.2.1 Scarifying Asphalt Course

Cold Milling Machine shall remove asphaltic course to a depth as specified in drawings or as directed by the Engineer. Milling Machine shall be controlled by electronic devices to ensure removal of materials to a specified depth and grade.

308.2.3.2.2 Mixing of Reclaimed Material

Job Mix Formula for the admixture will be based on material analysis of existing pavement by bitumen extraction and sieve analysis. Material to be added may be asphalt binder or aggregate, which will be calculated to ensure preparation of proper final mix.

308.2.3.2.3 Laying and Compaction

Laying and preliminary compaction of mixed asphalt shall be effected by tamping and vibrating screeds of the recycling equipment. Screeds shall be able to lay the mix true to the levels and grades required by the drawings or as directed by the Engineer. Compaction shall be carried out by conventional equipment to achieve ninety seven (97) percent compaction with respect to the laboratory compaction achieved by the mixed asphalt as per Marshall method.

308.2.3.3 Job Mix Formula

Unless stated in the Contract Documents, the asphaltic concrete type shall be prepared according to relevant clauses of Item 203 and 305 and according to Hot-mix Recycling Asphalt Institute Series Manual (MS-20) with the following consideration:

RAP: One test for the asphalt content, gradation, and reclaimed asphalt penetration shall be done for every one thousand (1000) cubic meter of RAP, with minimum of five (5) tests in all cases.

Added Aggregate: The added aggregate, when blended with the RAP, shall conform to all quality requirements specified in Table 308-4. The gradation shall be determined with the RAP according to the targeted gradation from applicable Item 203 or 305 of this specification.

Asphalt Materials: Type, grade, and quantity of asphaltic material, and recycling agent (when used), shall be determined according to the following criteria:

1. It must conform to the specific requirements of asphaltic mixture.
2. The combined asphaltic material in the final mixture shall have a viscosity conforming to the selected grade of Asphalt as per site conditions.

TABLE 308-4: Aggregate Quality Requirements for Asphaltic Mixes

Test	Test used	Limits	
		Asphalt Base Course	Asphalt Wearing Course
Loss Angeles abrasion, percent, max	AASHTO T-96	40	30
Sand equivalent, particles passing sieve No. 4%, min	AASHTO T-176	45	45
Flat and elongated particles ratio of max dimension to the min is 2.5:1, % max (by weight)	ASTM D-4791	15	10
Liquid limit, max	AASHTO T-89	25	25
Plasticity index for aggregate passing sieve No. 40, min	AASHTO T-90	6	4
Soundness %, min - Sodium Sulfate	AASHTO T-104	12	12
Percent fracture (two faces), for aggregate retained on sieve No. 4, min	ASTM D-5821	95	100

The Contractor shall furnish and submit a technical report including the JMF prepared by a skilled laboratory approved by the Client. The report shall include, but not limited to, the following:

1. The originals of the laboratory test results on the mix.
2. The originals of the laboratory test results on the RAP and added materials.
3. The percentage of RAP to be used, by total weight of mix.
4. The percentage of added aggregate to be used, by total weight of mix.
5. The gradation of added aggregate to be blended with the RAP and the gradation of the final aggregate.
6. The type, viscosity, and percent of asphaltic material to be added, by total weight of mix.
7. The type, viscosity, and percent of recycling agent to be added, by total weight of mix.
8. The viscosity of the final asphaltic material to be used in the mix.
9. The type and amount of mineral filler, chemical admixture, and asphalt modifier to be added by total weight of mix.
10. The type and location of plants to be used for mixing each mix to be furnished.
11. Construction methodology and Quality Control Program.
12. The proposed beginning date for producing hot-mix recycled asphaltic concrete mixtures.

The Engineer shall be provided access to the materials sampling and testing operations at all times.

308.2.3.4 Acceptance of Job Mix Formula

The Engineer shall review the JMF and all related matters, shown in previous Sub item, submitted by the Contractor according to the following steps:

1. Assure that the report contains all requirements. If it does not contain all required information, it shall be returned within seven (7) days to the Contractor for further action and resubmission by the Contractor.
2. If the proposed JMF contains all required information but fails to meet all of the requirements specified, it shall not be accepted by the Engineer and will be returned to the Contractor within fourteen (14) days. The Contractor shall prepare and submit to the Engineer a revised JMF conforming to the requirements specified.
3. The fist-day work shall be considered as a field control strip. It shall be assured that mix is constructible in terms of spreading, compaction, and smoothness level.

The Contractor shall not alter the methods of manufacturing, screening, mixing, stockpiling of aggregate, or production of asphalt mixtures since this alteration will mandate re-evaluation of JMF.

308.2.4 ON-SITE DEVIATIONS FROM JMF

Determining Aggregate Gradation and Asphalt Content in Recycled Mixes:
The asphaltic concrete aggregate gradation and asphaltic content will be sampled, tested and evaluated in accordance with AASHTO T-164. The extracted asphalt shall be reclaimed from the solution by Abson Method as per AASHTO T-170. The asphalt viscosity at 60 deg. C is subsequently determined according to AASHTO T-202. The allowable limit for payment purposes are as follows:

1. Aggregate gradation:
The upper and lower specification limits are the approved JMF target values plus or minus the allowable deviations shown below x (1 + the ratio of RAP material to the total mixture). Round to the nearest percent except for the 0.075 mm (No. 200) sieve that is rounded to the nearest 0.10%.

Allowable Combined Aggregates Gradation Deviation

Retained No. 4 and larger	± 7.0%
Passing No. 4 to No. 100 sieves	± 4.0%
Passing No. 200	± 1.0%

However, due to this variation in percentage of materials no individual sieve component shall fall outside the envelope given in Table 305-1 for Wearing Course or Table 203-1 for Base Course, for applicable class of combined gradation.

Example: If thirty percent (30%) of the mixture is reclaimed asphalt pavement material, then allowable deviation from target value for percent of aggregate retained on sieve No. 4 or larger is 7x(1.30) = 9.1%. Use plus 9.0% and minus 9.0% from the approved JMF target value for percent retained on sieve No. 4 or larger. Considering sieve No. 4, this variation shall not result in gradation to be outside 35-50% range (from Table 305-1) for Class-A gradation in Wearing Course.

2. Asphaltic material content. The upper and lower specification limits are the approved job-mix formula target value ±0.3 x (1 + the ratio of the RAP material to the total mixture rounded to the nearest 0.10%). However, minimum asphalt content in recycled mix shall not be less than 3.5%

Example: If thirty percent (30%) of the mixture is reclaimed asphalt pavement material, then the allowable deviation from target value for percent asphalt content is 0.3 x (1.30) = 0.39%. Use plus 0.4% and minus 0.4% from approved JMF target value for asphaltic material content. However, minus 0.4% shall only be valid if by applying this variation the asphalt content does not fall below 3.5%.

3. Asphalt viscosity. The allowable limits of asphalt viscosity variation in Recycled Asphalt Mix shall be equal to the approved asphalt viscosity in JMF plus or minus ten (±10) percent of approved viscosity.

Example: If JMF asphalt viscosity is hundred and Fifty (150) Pa-s, then the allowable limits will be (150 ± 0.1x150) = 135 to 165 Pa-s.

308.2.5 GENERAL REQUIREMENTS

The Recycled Asphalt layer shall fully meet all the requirements pavement thickness and tolerances as per Item 203 if it is to be used as Asphaltic Base Course or Item 305 if it is to be used as Asphaltic Wearing Course. Any other physical property essential for workmanship or quality control shall be fixed by the Engineer and contractor jointly. Physical properties of the fresh material shall correspond to the applicable requirements of such ingredients in these specifications. Frequency of tests for Hot Mix Asphalt Recycling shall be as mentioned in “Tables for Sampling and Testing Frequencies” in this specification.

308.3 HOT IN-PLACE RECYCLING

308.3.1 DESCRIPTION

The work under this item shall consist of softening the existing asphalt pavement with heat, milling/scarifying the top 20 to 60 mm and thoroughly remixing, leveling and compacting the milled/scarified material. The work items shall include the addition and mixing of recycling agents and the addition and mixing of new hot mix asphalt as required by the Engineer. The work shall be accomplished by a single pass of an equipment train which is capable of cleaning, heating, milling/scarifying, mixing, re-leveling, and compaction.

308.3.2 MATERIAL REQUIREMENTS

Material used in this item of work shall conform to Item 308.2.2 of these specifications.

308.3.3 CONSTRUCTION REQUIREMENTS

All relevant construction requirements of Item 305 shall be applicable for Hot Mix Recycled Asphalt treatment. Additionally, following considerations shall also be applicable

General: The hot in-place recycling shall be performed with self-propelled equipment that is capable of the following:

1) Softening the existing asphalt concrete surface by applying heat.
2) Milling/scarifying the surface to the depth shown on the plans.
3) Blending and mixing recycling agent and/or new hot mix asphalt and/or new aggregate.
4) Spreading and leveling the heated material and;
5) Compacting the resulting mixture to the desired air void content. This (5) operation shall be accomplished with a single pass of the equipment train.

Cleaning of Existing Surface: The existing paved surface to be recycled shall be cleaned of all dirt, fabric, thermoplastic markers, rubberized materials, oils and other objectionable materials by blading, brooming, flushing with water or other approved methods prior to beginning hot in-place recycling.

Heating and Milling/Scarifying: The pavement surface shall be evenly heated up to a temperature of one hundred and ninety (190) deg. C, milled/scarified and reworked to the widths and depths shown on the plans. There shall be no burning or scorching of trees, shrubs or other items near the recycled pavement. It shall be the responsibility of the contractor to protect the adjacent landscape from damage by shielding and/or water spray or other methods approved by the engineer. The heated and milled/scarified materials shall have a temperature in a range between 135-160 degrees C as measured immediately behind the laydown machine. The temperature shall be selected within this range to provide for adequate compaction.

Blending, Mixing, Spreading and Leveling: The recycled pavement materials, recycling agent (if required), new hot mix asphalt (if required), and new aggregate (if required), shall be fed into a mixing unit and thoroughly mixed. The resulting mixture shall be fed into a spreading and leveling unit.

Joints: The heating unit shall supply heat a minimum of 100 mm beyond the width of recycling. When a pass is adjacent to a previously placed mat, the heating shall extend 150 mm into the adjacent mat and the joint shall be located a minimum of 100 mm into the previously placed mat.

Compaction: The compaction operation shall meet the density/air void requirements of Item 305 of these Specifications. All compaction shall be complete prior to the mixture temperatures falling below 110°C.

Regulation: The contractor shall be required to meet “Pakistan Environmental Air Quality and Emission Standards (2001)” and all workforce health and safety standards.

Test Strip: At the beginning of the hot in-place recycling operation, the contractor shall construct a test strip on the project, a minimum of 150 meters but not more than 300 meters in length using the equipment and methods to be used for the remainder of the project. No further work shall be performed until the test strip is evaluated and the process approved by the Engineer.

308.3.3.1 Equipments

The Contractor shall furnish suitable equipment to execute the In-Place recycling work. The equipment used shall be capable of performing the completed work at a minimum rate of 575 square meters per hour of operation to the depth shown on the plans. The contractor shall provide the Engineer with details and technical specifications of all the plant and equipment to be used for the recycling work at least two weeks prior to the first proposed usage. The equipment shall include, but not limited to, the following:

308.3.3.1.2 Heater

The equipment used to heat and scarify the asphaltic surface shall be self-propelled, equipped to burn liquid petroleum gas (LPG) or natural gas. Diesel fuel shall not be allowed. The combustion chamber shall be insulated to avoid the flame to contact the asphalt, rear wheel positioned, and equipped with calibrated burners which shall be capable of heating the asphaltic surface to a temperature of one hundred and ninety (190) degrees Celsius plus or minus ten (±10) degrees Celsius, to a depth between twenty and thirty (20-30) millimeters. Additional heater units, without scarifier rakes, shall be operated in advance for preliminary heating. Heater-scarifying equipment shall be capable of being adjusted to heat widths between two and four (2-4) meters.

These units shall impart thermal energy to the asphalt pavement without charring the asphalt binder and without producing 1) unacceptable health risks to the contractor's workforce and citizenry, 2) unacceptable air quality, 3) direct flames on the pavement surface and 4) breaking aggregate particles. The heating unit shall be so equipped that heat application shall be under an enclosed or shielded hood. Each heating unit shall contain safety equipment to minimize workforce injury.

308.3.3.1.3 Scarifier

The machine shall be equipped with two (2) rows of spring equalized scarifier-leveling rakes capable of removing the pavement to the desired depth which will automatically ride over obstructions in the surface such as man-hole covers. These units shall contain a rotating drum with cutting teeth and/or an acceptable scarifier which uniformly loosens the heated asphalt pavement to the depth specified. Automatic grade and cross slope controls shall be required on the final pavement removal unit in the equipment train. The equipment shall be capable of height adjustments in order to clear utility hardware and other obstructions in the pavement surface.

308.3.3.1.3 Distribution and Blending Unit(s)

Units capable of uniformly distributing recycling agents and mixing hot mix asphalt shall be integral components of this equipment. This mixing equipment shall be capable of uniformly mixing recycling agent, hot mix asphalt and other materials as specified by the engineer. This equipment shall be capable of providing the following:

1. Positive feed and shut-off of the recycling agent linked to the movement of the machine.

2. Control of the quantity of the recycling agent to plus or minus 0.25 liters per square meter of surface treated with a recycling agent application range of from 0.1 to 2.0 percent recycling agent by weight of recycled mixture.

3. Proportional interlinking of the recycling agent application rates to the machine's processing rate.

4. Heating the recycling agent to within plus or minus 14℃ of the temperature of the recycled material.

5. Measurement of the amount of recycling agent by means of a device capable of recording accumulated volume to an accuracy of plus or minus 2.0 percent.

6. Uniform mixing of recycled pavement and new hot mix asphalt in a pugmill or continuous mixing chamber such that the specified proportion of new hot mix asphalt can be accommodated.

308.3.3.1.4 Spreading and Leveling Unit

A unit capable of spreading and leveling the blended and mixed recycled material uniformly over the width being processed and to the finished grade and cross slope as specified on the plans shall be provided. This unit shall have characteristics equivalent to those associated with conventional hot mix asphalt laydown machines and shall contain automated grade and cross slope controls.

308.3.3.1.5 Compaction Equipment

Compaction equipment shall be supplied in accordance with Item 305 of these Specifications to complete the job as specified.

308.3.3.2 Job Mix Formula

The Job Mix Formula shall be prepared as per Item 308.2.3.3 and acceptance of Job Mix formula shall be in accordance to item 308.2.3.4. Requirements of Item 305 shall be applicable for In-Place Recycled Asphalt.

Design Information: The mixture design submitted shall include the following information:

1. Asphalt binder content of the asphalt pavement to be recycled.
2. Penetration at 25°C (77°F) and viscosity at 60°C (140°F) of asphalt cement contained in the asphalt pavement to be recycled.
3. Gradation of the asphalt pavement to be recycled.
4. Gradation of new aggregate (as required).
5. Percent asphalt cement added to the new aggregate (as required).
6. Type and amount of recycling agent (as required).
7. Penetration at 25°C (77°F) and viscosity at 60°C (140°F) and 135°C (275°F) of recycled mixture (includes asphalt from pavement to be recycled, new asphalt cement and recycling agent).
8. Aggregate gradation of recycled mixture (includes aggregate in pavement to be recycled and new aggregate).
9. Stability and volume analysis information as described in the Asphalt Institute Manual, Series (MS-2).

308.3.4 ON-SITE DEVIATIONS FROM JMF

Allowable on site deviation from designed JMF shall be in accordance to Item 308.2.4. Requirements of Item 305 shall be applicable for In-Place Recycled Asphalt.

308.3.5 GENERAL REQUIREMENTS

The In-Place recycled Asphalt layer shall fully meet all the requirements pavement thickness and tolerances as per Item 305.3.2. Any other physical property essential for workmanship or quality control shall be fixed by the Engineer and contractor jointly. Physical properties of the fresh material shall correspond to the applicable requirements of such ingredients in these specifications.

308.3.6 QUALITY CONTROL

Before starting construction, quality of existing pavement shall be evaluated, in terms of aggregate gradation and asphalt content of the mix. The pavement shall first be delineated into subprojects, on the basis of differences in design, maintenance and rehabilitation actions. Once the subprojects are identified, samples shall be taken from each of the subprojects to obtain representative materials. In this way the variation in the existing material shall be identified and evaluated.

In hot in-place recycling, the softened material from the existing pavement is scarified and re-compacted after mixing with recycling agent. Samples of in-place mix shall be obtained from the laydown machine for checking the mix components such as gradation and asphalt content. The scarified existing material shall also be sampled behind the scarifiers. The National Center for Asphalt Technology (NCAT) "Ignition Oven" (AASHTO T-308) shall be used to determine the amount of asphalt binder (or recycling agent) being incorporated in the recycled mix by checking the asphalt content of the existing, scarified mix and the asphalt content of the recycled mix. Alternatively AASHTO T-164 method may also be used for this purpose.

Frequency of tests for Hot In-Place Asphalt Recycling shall be as mentioned in "Tables for Sampling and Testing Frequencies" in this specification.

Recommended guidelines for Quality Control are presented in Table 308-5, the Engineer may decide regarding frequency of implementation of these guidelines in addition to the tests mentioned in "Tables for Sampling and Testing Frequencies", based on the specific project requirements.

Table 308-5: Quality Control for Hot In-Place Recycling Process [a]

Item	Recommended Method [b]
Width	As usual
Depth of Scarification	Measure depth from existing surface adjacent to second mixer
Rejuvenator Application Rate (if any)	ASTM D 4887 Calculate from quantity used
Rejuvenator Quality (if any)	As usual (specifications and ASTM D 4552)
New Mixture Addition Rate (if any)	Calculate from quantity used (tons) and in-place density
Thickness of New Hot-Mix Overlay (if any)	Calculate from quantity used (tons) and in-place density
Temperature at Breakdown Rolling	Monitor at mid-point of re-profiled depth
Temperature of New Hot-Mix (if any)	As usual
Asphalt Cement Content, Gradation, and Stability Requirements	As usual
Compaction	As usual. Important to compare to relevant re-compacted density
Surface Tolerance	As usual
Viscosity and Softening Point of Asphalt Extracted from Recycled Mixture	As usual

Notes:

a) As the HIR processes are largely based on conventional hot-mix paving technology, it is only necessary to supplement the usual quality control requirements. The quality control items and frequency of testing should be established at the level necessary to ensure specification compliance.

b) All testing should be done on random, representative samples, by qualified technicians in a certified laboratory.

308.4 COLD IN-PLACE RECYCLING

308.4.1 DESCRIPTION

Cold In-place Recycling (CIR) is defined as a rehabilitation technique in which the existing pavement materials are reused in place. The materials are mixed in-place without the application of heat. The reclaimed asphalt pavement (RAP) material is obtained by milling / planning, or crushing the existing pavement. Virgin aggregate or recycling agent or both are added to the RAP material which is then laid and compacted all as shown on the plans, specified in these General Specifications or the Special Specifications. The recycled pavement, by this method, is used in asphaltic concrete base course in the same site. These base layers shall be covered by a surface treatment or an asphaltic wearing course.

308.4.2 MATERIAL REQUIREMENTS

Material used in cold In-Place Recycling shall conform to the following:

308.4.2.1 Asphaltic Material

Material specifications for asphalt emulsion shall correspond to Item 313 of this specification. The emulsions typically used for cold recycling are medium setting grades of regular MS and CMS, high float HFMS and polymer modified versions of these grades. Emulsified recycling agents, if required, shall conform to ASTM D-5505.

However, the type of asphalt emulsion to be used shall be determined by the mix design.

308.4.2.2 Cold Pulverized Material

The cold pulverized material shall meet the gradation requirement shown in Table 308-6 prior to the addition of the asphalt emulsion.

Table 308-6: Gradation Requirements for Cold Pulverized Material

Sieve Size	%Passing
2.0 inch	100
1.5 inch	80 - 100

308.4.2.3 Water

Water shall be free from an excessive amount of acids, alkali, oil, and other substances, which will cause damage to the materials used.

308.4.2.4 Other Additives

If necessary, additives may be used to meet the durability requirements of road. In the case that an additive is used, the type and allowable usage percentage must be described in the submitted mix design recommendation for approval. Active fillers e.g. cement or hydrated lime are used to stabilize Bitumen.

308.4.2.5 Additional Aggregates

Based on the results of the mix design or other requirements, the contractor shall determine if additional aggregate is required. Any additional aggregate shall meet the requirements in Table 308-4, and it shall be graded to produce a product that meets one of the gradations of Asphalt Institute MS 21.

308.4.2.6 Fog Seal

The contractor shall apply a fog seal to all areas as directed by the Engineer prior to opening the lane to uncontrolled public traffic. Asphaltic emulsion (fog seal coat) shall be applied to the surface of the CIR material and shall be grade SS-1, SS-1h, CSS-1 or CSS-1h asphalt emulsion, based on the affinity with aggregates, unless otherwise ordered by the Engineer. All asphaltic emulsion materials shall be diluted 50/50 with water before application. The application rate of the fog seal coat (asphalt emulsion and equal amounts of water) shall be such that the diluted asphaltic emulsion will be spread at a rate of 0.45 liters per Sq. meters to 0.70 liters per sq. meters. The exact rate of application will be determined by the Engineer based on surface condition, texture and dryness of pavement surface.

Following the application of the fog seal, sand will be spread over the entire fog sealed area at a rate of 1.2 Kg ± 0.20 Kg per sq. meters.

308.4.3 CONSTRUCTION REQUIREMENTS

308.4.3.1 Equipment

All plant and equipment shall be supplied and operated in such a manner as to recycle in situ pavement material to the specified depth and construct a new layer, all in accordance with the requirements of the specifications. All plant and equipment deployed on the site shall be of adequate rated capacity and in good working order. Obsolete, poorly maintained, or dilapidated plant will not be allowed on site. The minimum compliance requirements for plant and equipment to be used for the recycling work are given in the following sub-clauses. The contractor shall provide the Engineer with details and technical specifications of all the plant and equipment to be used for the recycling work at least two weeks prior to the first proposed usage.

308.4.3.1 Pavement Recycler

Recycling shall be effected by utilising a purpose-built self propelled recycler to recover the material in the upper layers of the existing pavement and blend together with any imported material pre-spread as a uniform layer on the existing road surface. The machine employed shall be capable of achieving the required grading and consistency of mix in a single pass. As a minimum, the recycler shall have the following features:

- It shall be factory-built by a proprietary manufacturer having a demonstrable track record and manufacturing history in the particular type of equipment;
- If older than 10 years, the machine shall be certified by the manufacturer or manufacturer's authorized agent to confirm operational fitness-for-purpose dated not more than 3 months earlier than the date on which it commences work on the project;
- The milling drum shall have a minimum cut width of two (2) meters with the capability of changing the speed of rotation. The machine shall be capable of recycling to a maximum depth, as specified, in a single pass;
- A level-control system that maintains the depth of milling within a tolerance of plus minus ten (±10) millimeters of the required depth during continuous operation;
- The milling drum shall rotate within an enclosed chamber inside which water and stabilising agents are added to the recovered material at the rate required to achieve compliance with the specified laboratory mix design during a continuous operation.

- All spray systems fitted to the recycler shall be controlled by micro-processor to regulate the flow rate with the speed of advance of the machine. All spray systems will also have the ability to allow variable widths of application;

- The recycler shall have sufficient power to mix the recycled material together with all additives to produce a uniform homogenously mixed material during continuous operation.

- To supply the bitumen emulsion at the required application rate to comply with the mix design during continuous operation;

- To regulate the application rate of bitumen emulsion in accordance with speed of advance of the recycler and volume of material being recycled;

- To provide uniform application of the bitumen emulsion to the recycled material to produce a homogenous mixture;

- A method for monitoring bitumen emulsion application during operation that can be reconciled by simple physical measurement for control purposes.

If foamed bitumen is used in cold recycling, the Recycler shall have following additional features:

- A series of expansion chambers mounted equidistant on the spray bar (maximum spacing 200 mm) for creating the foamed bitumen;

- The capability of providing a constant supply of foamed bitumen at the required rate to comply with the mix design during continuous operation;

- Capable of regulating the quality of foamed bitumen and regulating the application rate in accordance with speed of advance of the recycler and volume of material being recycled;

- Provide a uniform application of the foamed bitumen across the width of application to produce a homogenous mixture;

- A method for monitoring bitumen application during operation that can be reconciled by simple physical measurement for control purposes;

- Functioning temperature and pressure gauges on the bitumen supply line for monitoring purposes;

- A means of demonstrating that all expansion chambers are producing foamed bitumen at any time during the operation (no blockages);

- A means of providing a representative sample of foamed bitumen at any stage during normal operations (test nozzle).

The mixed material shall exit from the mixing chamber in a manner that prevents particle segregation and be continuously placed back in the excavation created by the recycler as it advances. Spreading and placing to form the new layer shall be carried out by a motor grader only after the primary compaction has been achieved (unless placed by a screed mounted on the rear of the recycling machine).

308.4.3.2 <u>Cement Slurry Unit</u>

The recycler shall be fed with cement slurry that is produced in a separate mobile mixing unit pushed ahead of the recycler. Such a mixing unit shall have the following minimum features:

- The capability of supplying the cement slurry at the required rate to comply with the mix design during continuous operation;
- Capable of regulating the application rate of cement slurry in accordance with the speed of advance of the recycler and volume of material during continuous operation;
- Provide uniform application of cement slurry to the recycled material to produce a homogenous mixture;
- A micro-processor controlled method for monitoring cement usage during operation that can be validated by simple physical measurement for control purposes.

308.4.3.3 Compaction Equipment

Initial compaction of the recycled material shall be undertaken using a heavy smooth-drum or padfoot vibrating roller operated only in high-amplitude vibration mode. The static mass of the roller to be used shall be in determined by the thickness of the recycled layer, in accordance with the following table 308-7:

Table 308-7: Compaction Equipment

Thickness of compacted layer	Minimum static mass of roller (tons)
< 150 mm	12
150 mm to 200 mm	15
201 mm to 250 mm	19
> 250 mm	24

The operating speed of the primary roller shall never exceed 3 km / hr and the number of passes applied over the full width of each cut shall be sufficient to achieve at least the specified layer density in the lower two-thirds of the layer.

308.4.3.4 Oil Tankers

Only tankers with a capacity exceeding ten thousand (10,000) liters shall be employed to supply the recycler with bitumen stabilising agents. Each tanker shall be fitted with two recessed pin-type tow hitches, one in front and one at the rear, thereby allowing the tanker to be pushed from behind by the recycler, and to push a water tanker in front. No leaking tanker will be permitted on the site. In addition, each tanker shall be equipped with:

- A functioning thermometer to show the temperature of the contents in the bottom third of the tank;
- A rear feed valve, with a minimum internal diameter of 75 mm when fully opened, that is capable of draining the contents of the tank.

Where foamed bitumen is applied, the following additional requirements shall be met:

- All-round cladding to retain heat;
- A heating system capable of raising the temperature of the contents of the tank by at least 20° C per hour.

308.4.3.2 Construction Procedure

The exact locations of the areas to be recycled along with the respective thicknesses thereof shall be determined and delineated by the Engineer immediately prior to the start of the Work. The construction process shall involve pulverization, mixing, and compaction.

308.4.3.2.1 Pulverization

The Contractor shall submit to the Engineer prior to the start of the work the proposed pulverization method for the existing pavement and the addition and mixing in place of any required new aggregate and new asphalt or recycling agent. The resultant mixture shall be spread, compacted, and finished.

The Contractor shall pulverize the existing pavement to the required size and shall add any amount of new aggregate and asphalt required by JMF.

Undesirable contamination of the reclaimed materials with underlying untreated base course or subgrade materials, clay, silt, or other deleterious matter shall not be accepted. Should such undesirable contamination occur, as determined by the Engineer, the materials shall be discarded as directed and shall be replaced with new approved materials, all at the Contractor's expense.

308.4.3.2.2 Mixing

Mixing asphaltic materials and/or recycling agent with RAP shall be uniform using any of the following methods:

1. The asphaltic material and/or recycling agent may be applied through the machine used to cold mill the asphaltic surface as a part of the liquid used to cool the cutter teeth, provided it is applied uniformly across the width of cut and results in a complete and uniform blending of all materials.
2. The cold mix recycled asphaltic base may be produced using a continuous operation consisting of an interconnected cold milling device, portable crusher mounted on a trailer, cold mixing pugmill mounted on a trailer, paving machine, materials transfer belts for moving the materials from milling equipment through to the paving machine and compaction equipment. When new aggregates are required they shall be spread uniformly at the approved quantity on the road surface in advance of the cold milling machine.

Regardless of which method is used, mixing equipment shall have accurately meter to inject planned amount of asphaltic material and/or recycling agent into the RAP and aggregate.

When directed by the Engineer, water shall be added to the RAP to facilitate uniform mixing with asphaltic materials. Water may be added prior to or concurrently with adding the asphaltic materials, as approved by the Engineer.

308.4.3.2.3 Placing and Compaction

The recycled mixture shall be compacted using pneumatic or steel-drum tandem roller (vibratory or normal) until the compacted density of recycled mixture is at least ninety-seven (97) percent from the Marshall laboratory compacted specimen determined from ASTM D 2726.

The cold in-place recycled asphalt treated base shall be compacted to a density approved by the Engineer. The Contractor shall prepare a three hundred (300) meters test section. A combination of steel wheeled, under static or vibratory mode, and pneumatic rollers will be used to establish what combination will yield the maximum density. Rolling or roller patterns shall be established at the beginning of each day's work, or a change when major displacement and/or cracking of the recycled material occurs, or a change in mix design. Rolling shall start no more than 15 minutes behind the screed. Vibratory mode shall only be used if it is shown not to damage the pavement. When possible, rolling shall not be started or stopped on uncompacted material but with rolling patterns established so that they begin or end on previously compacted material or the existing pavement. Rolling shall be longitudinal and commence at the outer edges of the road and progress toward the centerline. In super elevated curves, the rolling shall begin at the low side and progress to the high side. Where paving is abutting a previously placed lane, compaction shall begin with the

roller entirely on the new mat and the edge approximately 6 inches from the joint. Both passes (forward and backward) shall be made in vibratory mode with the second pass overlapping the cold lane by 6 inches. Final rolling, to eliminate pneumatic tire marks and to achieve density shall be done by double drum steel roller(s), either operating in a static or vibratory mode. Finish rolling shall be completed no more than two hours after milling is completed.

After the recycled mixture has been spread and compacted, it shall be allowed to cure so that moisture content is reduced below one and a half (1.5) percent prior to placing a wearing surface. If wearing course is not to be placed, Fog seal shall be applied as temporary protection against raveling prior to opening the road for traffic. Additional curing time may be required by the Engineer in the event that the recycled mixture becomes wet during rainfall. Any damage to the recycled mixture shall be repaired by and at the Contractor's expense and to the satisfaction of the Engineer.

308.4.3.2.4 Surface leveling

After each working day, the final surface after completion of compaction shall be tested for leveling, and shall have no depressions under a five (5) meter straightedge greater than five (5) millimeters when laid parallel or transverse to the centerline.

308.4.3.3 Job Mix Formula

Job Mix Design shall be carried out as per Asphalt Institute Manual Series No. 21 (MS 21). The Asphalt Institute mix design method consists of the following steps:

1. Determination of combined aggregate gradation (for virgin and RAP aggregates). The prerequisite to this step is determination of gradation of aggregate and asphalt content of the RAP material.
2. Selection of grade of new asphalt binder.
3. Determination of percent asphalt demand of the combined aggregate on the basis of suggested empirical formula.
4. Calculation of percent of new asphalt in the mix.
5. Field mix trial for adjusting asphalt content.

The laboratory JMF shall be continuously adjusted at site by the Engineer based on the site trial mix performance and considering durability requirements of road.

308.4.3.4 Weather Limitations

Cold In-Place recycling shall not be carried out during rainfall, dust or sand storms, or when the ambient temperature is less than five (5) degrees Celsius or it is anticipated that temperature will fall below five (5) deg. C within 48 hours of mixing at project site. CIR shall not be carried out when weather conditions prevent specified mixing and compaction requirements.

CIR may be started if the anticipated atmospheric temperature is 15 deg. Celsius and rising at the project site by 10 00 am when starting recycling operations prior to 10 00 am.

308.4.4 QUALITY CONTROL

Before starting construction, quality of existing pavement shall be evaluated, in terms of aggregate gradation and asphalt content of the mix. The pavement shall first be delineated into subprojects, on the basis of differences in design, maintenance and rehabilitation actions. Once the subprojects are identified, samples shall be taken from each of the subprojects to obtain representative materials. In this way the variation in the existing material shall be identified and evaluated.

"Tables for Sampling and Testing" present the material sampling and testing procedures for quality control of Cold In-Place Recycling procedure. However, as CIR requires a high degree of monitoring for successful completion of job, the Engineer shall decide the frequency of tests based on site conditions and any additional tests as per requirements of the job.

308.5 FULL DEPTH PAVEMENT RECLAMATION (FDR)

308.5.1 DESCRIPTION

Full depth reclamation has been defined as a recycling method where all of the asphalt pavement section and a predetermined amount of underlying materials are treated to produce a stabilized base course. Different types of additives, such as asphalt emulsions and chemical agents such as calcium chloride, portland cement, fly ash and lime, are added to obtain an improved base. The five main steps in this process are pulverization, introduction of additive, shaping of the mixed material, compaction, and application of a surface or a wearing course. If the in-place material is not sufficient to provide the desired depth of the treated base, new materials may be imported and included in the processing. This method of recycling is normally performed to a depth of 100 to 300mm.

308.5.2 MATERIAL REQUIREMENTS

All Material used in Full Depth Recycling operation shall conform to Item 308.4.2

308.5.3 CONSTRUCTION REQUIREMENTS

308.5.3.1 Equipment

All plant and equipment shall conform to Item 308.4.3.1. FDR shall be carried out by single pass equipment train. The recycler shall be capable of reclaiming the existing asphalt pavement and underlying granular base to the depths specified in the Contract Documents, incorporating corrective aggregate into the mix adding expanded asphalt in a controlled manner, and producing a uniform mix.

The drum of recycler shall be operated in down cutting mode for FDR operations.

308.5.3.1 Construction

Construction specifications as mentioned in Item 308.4.3 (including all sub-items) shall be followed for FDR in addition to the following:

The existing asphalt pavement and underlying granular base shall be reclaimed to the depths and widths specified in the Contract Documents.

The graded surface of the reclaimed material, including existing shoulders shall be according to the surface tolerance requirements of Item 203. The material shall be compacted according to requirements of Item 203.

In-place full-depth reclamation including mixing, shaping, and compacting to final grade shall be completed across the full pavement width prior to closing down operations each day. The existing shoulders shall also be shaped and compacted to match the adjacent lane prior to closing down operations each day.

The following additional guidelines shall be followed for full depth reclamation.

1. The unbound base course must be free of 100-mm cobbles, large boulders, rocks and vegetation etc.

2. Following limitations shall apply for cold pulverized material in FDR operation.

Table 308-8: Gradation Requirements for Cold Pulverized Material

Sieve Size	%Passing
2.0 inch	100
1.5 inch	80 – 100
No. 200	3.0

Where sub-grade instability is identified either by preliminary investigations, or during the recycling process, it shall be treated by:

- Recovering the material in the pavement layers overlying the unstable material by either milling or excavating and loading into trucks for transport to temporary stockpile;
- Excavating the unstable material to the prescribed depth, and removal to spoil;
- Treating the exposed roadbed, as specified; and backfilling the excavation using both temporary stockpiled and imported material.

Backfilling shall be undertaken in layers not thicker than 200 mm after compaction, and shall continue in successive layers until the level of the existing road surface is reached, whereupon recycling shall continue.

308.5.4 QUALITY CONTROL

Quality control measures as mentioned in Item 308.4.4 shall be followed for FDR operations.

308.6 MEASUREMENT AND PAYMENT

308.6.1 Measurement

The quantity of recycled asphalt pavement shall be measured in cubic meters of pavement structure removed, transported, recycled, relayed and compacted after mixing of other ingredients such as asphaltic binder, emulsion, recycling agent or fresh aggregates etc.

308.6.2 Payment

The quantity measured as provided above shall be paid at the contract unit price per cubic meter as shown in B.O.Q., acceptably laid and compacted in place, which payment shall be deemed to include full compensation for furnishing all materials, Labour, equipments, tools and incidentals necessary to complete the item.

Payment for pavement recycling shall be made separately under relative items of work as given below:

Pay Item No.	Description	Unit of Measurement
308 a	Hot Mix Recycling of Asphalt Concrete	CM
308 b	Hot In-Place Recycling of Asphalt Concrete	CM

308 c	Cold In-Place Recycling of Pavement	CM
308 d	Full Depth Recycling of Pavement	CM
308 e	Fog Seal	SM
308 f	Bitumen Grade _____	Ton
308 g	Cement (OPC Type-I)	Ton
308 h	Hydrated Lime	Ton

SECTION 309 COLD MILLING

309.1 DESCRIPTION

This work shall consist of milling (cutting) of concrete or asphaltic layer to a designated level and width by means of Specialized Equipment, removal of cut material and disposal as per Special Provision or as directed by the Engineer.

309.2 CONSTRUCTION REQUIREMENTS

Specialized equipment to be used for this item of work shall be capable of following operations:

i) Milling drum shall be capable of level and grade adjustments and it shall have variable speed provision to ensure production of smooth or rough milled surface.

ii) The cold milling machine shall be equipped with an electronically controlled leveling device which will produce the grade and cross-slope specified, and it shall be able to ride-over obstacles such as manhole covers. Level and grade control shall be ensured through electronic sensors, capable of giving an accuracy of ± two (2) mm.

iii) Scraper bars and belt conveyor system shall ensure picking and loading of milled material in a truck.

iv) The machine shall have a water tank, pump and spray bar for applying cooling water to the teeth during cutting and for control of dust.

309.2.1 Construction Procedure

Area shall be earmarked with respect to depth of milling, which shall be split in strips looking to the width of milling drum and width of area to be milled.

Milling machine shall be adjusted to cut to required depth. Milling drum shall be correlated to sky or string line arrangement to ensure milling according to required grade and profile.

Milling shall proceed from one edge of the road, strip by strip in a manner that may ensure resulting surface even and level.

Milled material shall be removed and disposed as per Special Provision or as directed by the Engineer.

Milled surface shall be cleaned by wire brushes or compressed air for subsequent operation.

309.3 MEASUREMENT AND PAYMENT

309.3.1 Measurement

The quantity of cold milling to be paid shall be measured by the number of square meters of area milled and cleaned as described above, as per drawings or as directed by the Engineer. No allowance will be given for milling out side the approved limit. Any such area milled beyond approved limits, shall be reinstated by the Contractor at his own expense.

309.3.2 Payment

The accepted quantity measured as provided above shall be paid at the contract unit price per square meter of cold milling for the pay items as listed below and in the B.O.Q., which price and payment shall constitute full compensation for labour, equipment and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
309 a	Cold milling, 0 - 30 mm	SM
309 b	Cold milling, 0 - 50 mm	SM
309 c	Cold milling, 0 - 70 mm	SM

SECTION 310 CONCRETE PAVEMENTS

310.1 DESCRIPTION

This work shall consist of a pavement composed of Portland cement concrete with or without reinforcement as specified, constructed by fixed form or slip form paving methods, on a prepared subgrade or base course in accordance with these specifications and in conformity with the lines, grades, thickness and typical cross-sections shown on the plans. Both plain and reinforced concrete shall include deformed bars for contraction joints and dowel bars for expansion joints or as shown on the Drawings.

310.2 MATERIAL REQUIREMENTS

310.2.1 Concrete

Concrete materials shall conform to the requirements indicated in item 401 and as specified hereinafter. In addition to it the contractor shall advise the Engineer immediately after the award of the contract of the source of all materials to be used in proportioning concrete for the work. If the contractor later proposes to obtain materials from a different source, he shall notify the Engineer at least thirty (30) days before such materials are to be used.

310.2.2 Reinforcing Steel

Concrete reinforcement shall conform to item 404 or as indicated on the Drawings. If required, steel fabric for reinforcement of concrete shall conform to AASHTO M 55. It must be supplied in sheets.

310.2.3 Polythene Sheeting

Polythene sheeting for placing immediately below concrete slabs shall comply with ASTM D-2103. Thickness of the sheet shall range from 0.15mm to 0.20mm. It shall be made from polythene or other approved hydrocarbon thermoplastic resin (produced by the polymerization of ethylene under high pressure and density) and given an anti-static treatment to reduce dust attraction and reduce friction. The sheeting shall have the minimum mechanical properties shown in table as under:

Table 310-1: Properties of Polythene Sheeting

Properties	Machine Direction	Transverse Direction.
Tensile Strength Method ASTM D-882 Kgf/SM	140	105
Elongation at Break %	150	500
Tear Strength Elmendorf Method ASTM D-689 - Kg/cm^2	390	310

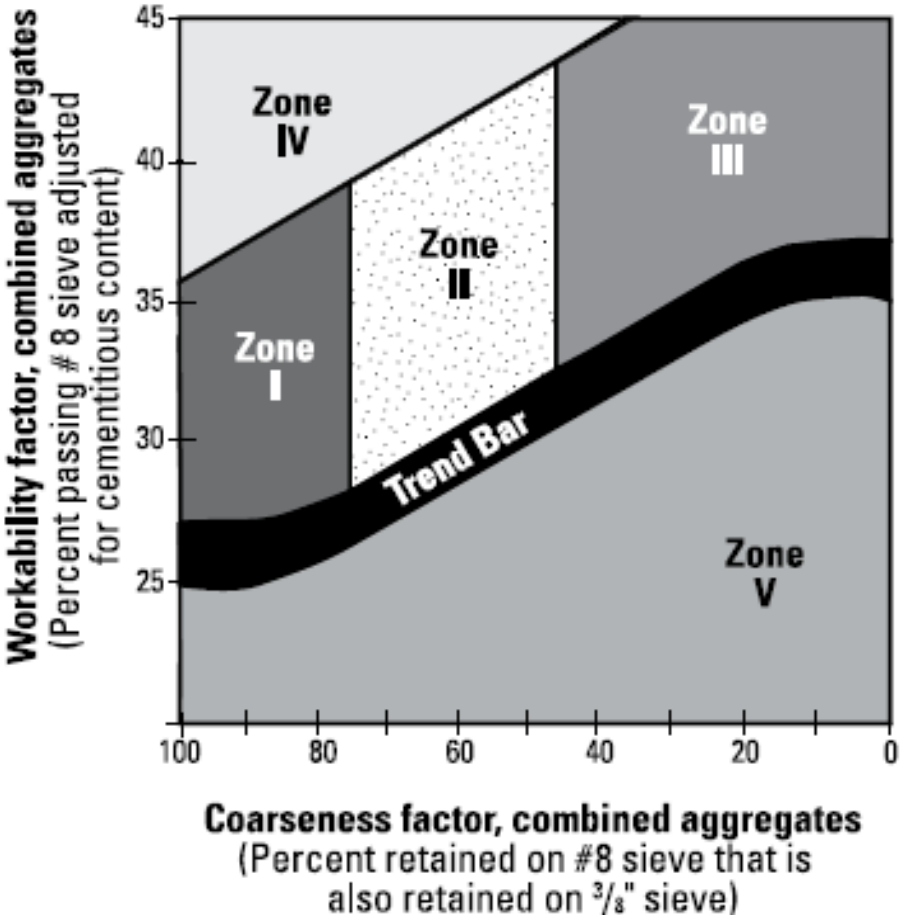
310.2.4 **Combined Aggregate Grading Requirement**

Combined Aggregates grading for concrete shall be such that plot of Coarseness and Workability Factors shall fall within Zone-II in Figure 310-1

$$\text{Coarseness Factor} = \frac{\%\ \text{Retained on 9.5mm (3/18") Sieve}}{\%\ \text{Retained on 2.36mm (\#8) Sieve}}$$

Workability Factor = % Passing 2.36mm (#8) Sieve ± adjustment
(Adjustment = add or subtract 2.5% for every 56 kg/CM of cement more or less than 335 kg/CM of cement in concrete)

FIGURE 310-1: MODIFIED COARSENESS FACTOR CHART



310.2.5 **Backer Rod**

Backer rod used in conjunction with joint sealers shall be of a composition approved by the Engineer. When used with hot poured sealers, the rod must withstand, without damage, the high temperatures inherent to the sealers. The backer rod shall have a maximum of 5% absorption when immersed in water for 24 hours with the ends sealed. The backer rod shall be of a size that compression is required for installation in the joint, so that it maintains its position during the sealing operation. Backer rod shall be dry.

310.2.6 **Joint Sealer**

Hot poured joint sealer shall be composed of petro polymers and be supplied in solid form. The sealer shall meet requirements of ASTM D-6690, or as approved by the Engineer.

Cold poured Silicone sealer shall comply with ASTM D-5893 or as approved by the Engineer.

The Sealer is to be impermeable, is to withstand all weather conditions and is to be capable of adhering to the concrete without cracking, spalling or disintegrating and will not require an impracticable condition of dryness or cleanliness of the concrete slabs. Where recommended by the manufacturer of the sealing compound, a primer supplied by him is to be used to improve adhesion.

Preformed Neoprene Joint Sealer

The Preformed Neoprene (Polychloroprene) joint seals of the open-cell compression type shall comply with ASTM D-2628 standard and shall be manufactured from a vulcanized elastomeric compound using polymerized chloroprene as the only base polymer. Neoprene shall make up at least 50% of the compound used in the manufacture of the seal. Some of the properties of Neoprene as per ASTM D-2628 are listed in the following table:

Table 310-2: Properties of Neoprene as per ASTM D-2628

Material Property	**Requirement**	**ASTM Method**
Tensile Strength min.	2,000 psi	D-412
Elongation at break, min	250%	D-412
Hardness, Type A Durometer	50 - 60	D-2240
After Oven Aging for 70 hrs. @ 100ºC		D-573
Tensile strength loss	20% Max	
Elongation loss	20% Max	
Hardness change	0 to +10 points	

The lubricant-adhesive used to install the Preformed Neoprene joint sealer shall be a one-component polychloroprene compound containing only soluble phenolic resins blended together with antioxidants and acid acceptors in a suitable mixture of organic solvents. The lubricant-adhesive shall comply with ASTM D-2835 and shall have the following properties:

- Solids Content 22 – 28%, by weight
- Viscosity shall be such that the lubricant will perform suitably with the installation equipment.
- The lubricant shall remain fluid from 5°F (-15°C) to 122°F (50°C).
- The lubricant should be kept from freezing and used within 250 days of manufacture.

310.2.7 Dowel Bars

Dowel bars shall be cut from plain mild steel bars (Grade 40) and will be approved by the Engineer. The Contractor's attention is directed to the requirement that one end of each dowel bar in all joints, except bonded construction joints, shall be sawn and not sheared so that no irregularities likely to interfere with its sliding action in the concrete shall occur.

The minimum length of the dowel bars spaced at one meter centre to centre or as shown on the drawings, shall be thirty five (35) times the diameter of the bar used unless otherwise specified or as directed by the Engineer. Except otherwise shown in drawings, diameter 32mm bars shall be used for slabs with thickness equal to or less than 200 mm and diameter 38mm bars for slabs with thickness that exceed 200 mm.

310.2.8 Expansion Caps

Expansion caps for dowel bars in expansion joints shall consist of pressed metal sleeves plugged at one end by punching the specified joint filler board of a wad of cotton waste of similar compressibility and sealed at the end against entry of mortar. The tube shall have an internal diameter permitting sliding on the dowel bar but close enough to prevent entry of mortar.

310.2.9 Tie Bars

Tie Bars shall be cut from Grade 40 or 60 deformed steel bars as specified in the drawings. Except otherwise shown in drawings, bars with diameters 13 mm shall be used for slabs of thickness 200 mm or less, and bars diameter 16 mm shall be used for slabs with thickness more than that.

310.2.10 Darkening Agent

Darkening agent for the top course of concrete pavements if ordered and specified shall be a carbon black; either as an aqueous dispersion containing at least 25% of solids, to be added to the mixing water, or as a self-dispersing powder to be added to aggregate and cement. It shall be approved by the Engineer as non-deleterious and as giving a grey colour and shall be added at the rate of 0.1% by weight of the mixed concrete if it is aqueous dispersion. The minimum quantity of self-dispersing powder shall be 0.025% by weight of the concrete aggregate.

The darkening agent shall be free from sulphur trioxide and from any other matter deleterious to concrete.

310.2.11 Crack Inducing Battens

Crack inducing battens shall be of wood or of any other suitable material proposed by the Contractor at the time of tendering and approved of at the award of the Contract or approved by the Engineer at his discretion after the award of the Contract. Battens of highly absorbent wood or other material shall be of cross-sectional dimensions shown on the Drawings, and treated to prevent adhesion between them and the concrete.

310.2.12 Sampling and Testing

All materials shall be approved by the Engineer prior to use in the work. Additional samples will be taken and tested by the Employer during the progress of the work to check on the quality of the materials being supplied and/or placed by the Contractor. The results of these tests will be available for the Contractor's use, however they are not intended for construction control purpose. The contractor should set up his own test facilities or arrange the same from a private laboratory, to assure that his materials and workmanship comply with the specification.

310.3 CONSTRUCTION REQUIREMENTS

310.3.1 Pavement Base

The base upon which the concrete pavement is laid shall be leveled compacted and true to the grades and cross-sections shown on the plans and shall be so maintained, as provided under such other items throughout the period of placing concrete pavement.

To ensure the proper depth and section, a scratch template true to depth and section and resting on accurately set side forms shall be moved over the surface immediately before placing concrete, and any irregularities shall be immediately corrected. High spots shall be planed down and the Contractor shall have the option of either filling low spots to the proper elevation with approved material, which shall be watered compacted and struck off to the required grade or of placing additional concrete. No measurement or payment will be made for such additional concrete.

Until the subgrade has been checked and approved, no material shall be deposited thereon . Storing or stock piling of materials on the subgrade and placing of surfacing material or laying of pavement on muddy or frozen subgrade will not be permitted.

310.3.2 Forms

If fixed form paving equipment is selected, side forms shall be made of metal of an approved section and construction provided with adequate devices for secure setting so that when in place, they shall withstand the impact and vibration of the compacting and finishing equipment with settlement not exceeding 1.5 mm in three (3) meters form a true plane surface on the top of the form and inside face shall not vary more than six (6) millimeters from a plane surface. The width of the bases of steel forms shall be not less than their height except that the forms having a base not less that two-third(2/3) of their height and meeting all other requirements herein may be used for manual laying of non rectangular bays.

The depth shall be equal to the thickness of the pavement at the edge or as shown on the plans. The forms sections shall be tightly joined by each joint free from play in any direction. These forms shall be stacked with steel stakes and shall be of a length approved by the Engineer. Each section of forms shall have stake pocket at each end and at intervals of not more than one and one-half (1:5) meters between ends.

Each section of forms shall be straight and free form bends and warps at all times.

Side forms for machine placing shall have rolled section steel rails which shall be of adequate stiffness to carry the laying, compaction and finishing machines.

These machines shall not run on folded sheet metal form tops. The top faces of the forms are to be carefully cleaned and maintained. The forms shall be without horizontal joints and with flange braces extending outward on the base not less than two-thirds the height of the forms. Each stack pocket shall be equipped with a positive non-detachable wedge. These forms shall be placed by using at least three steel pins of the size and length approved by the Engineer or as shown on the plans. They shall be equipped with positive locking devices which will permit neat tight joints and do not deform under impact vibration by thrust. Pins for stacking forms in place shall be made of steel at least two(2) centimeters in diameter as directed by the Engineer in case of impractical use.

Wooden forms may be used for curves having a radius of less than fifty (50) meters. They shall be made of two and half (2.5) centimeters well seasoned surfaced planks fastened together and shall be attached securely to a wooden base in width. All wooden forms shall be braced at least every sixty (60) centimeters with steel pins of the size and length here in specified. Straight forms shall be set out as chords to convex edges and as tangents to concave edges, but payment will not be made for concrete outside the curved edges shown on the Drawings.

Before placing forms the underlying material shall be excavated to the required grade, and shall be firm and compact. The forms shall have full bearings upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement.

Forms shall be set to the required lines and grades well in advance of placing concrete, preferably not less than two hundred (200) meters. Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Pavement which in the opinion of the Engineer is damaged due to the careless removal of forms shall be repaved by the Contractor as directed by the Engineer at the Contractor's own expense.

Forms shall be thoroughly cleaned and oiled each time they are used.

Special forms or other supporting devices meeting the approval of the Engineer shall be used to support the joint filler at transverse control joints when concrete is to be placed

on only one side of the filler. When pavement is placed adjoining existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true uniform surface of sufficient width to accommodate the wheels of the finishing equipment if necessary to obtain proper smoothness of the pavement.

310.3.3 Composition and Performance Parameters of Concrete

1. Composition

(a) All concrete shall be proportioned by weighing and shall conform to the following strength and mix requirements

i)	Compressive Strength, 28 days, minimum	250 kg/sq. cm.
ii)	Modulus of Rupture, 28 days, minimum*	40 kg/sq. cm.
ii)	Cement content, bags (50 Kg)	7.5 (min.)
iii)	Water cement ratio, maximum	0.45
iv)	Slump for Slip-form paving	12.5 – 50 mm
v)	Slump for Fixed-form paving	25 – 75 mm
vi)	Entrained air, percent	3 $\pm$ 0.5
vii)	Nominal size of aggregate, maximum	1.5 inch

* Modulus of Rupture test is optional and shall be carried out if required by the Engineer or mentioned in the special specifications.

(b) At least 35 days prior to the start of paving operations and after approval of all materials to be used in the concrete, the contractor shall submit for approval, the mix design he intends to use based on proportioned weights of cement, air entrainment agent, saturated surface dry aggregates and water. This mix design will be tested by the Engineer and approval will not be granted unless the average twenty eight (28) days compressive strength and Modulus of Rupture (if required) exceeds the minimum strength requirement by at least 15 percent. However, the Engineer may allow paving operation on the basis of seven (7) days strength if he is satisfied with the results of seven (7) days strength.

c) Modulus of Rupture test shall be performed as per ASTM C-78 with three point loading, on concrete beams casted from concrete taken from the batching plant / transit mixer.

d) The cement content given in the foregoing section is minimum. If it is not sufficient to produce concrete of the compressive or tensile strength specified it shall be increased as necessary without additional compensation under the contract.

e) The compressive strength of the concrete will be determined by testing standard cylinders made from concrete taken from the mixer. The making, curing and testing of the specimens will be in accordance with AASHTO T23-73.

f) During the course of construction, when the source of any material for the concrete is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strengths.

2. Consistency

The required consistency of the concrete mixture shall be such that the mixture will be cohesive, uniform and plastic, permitting proper handling and finish. When deposited it shall not flow, but shall remain in a conical pile. There shall be minimum of segregation and surplus water during the process of handling and finishing. The slump shall be

determined by AASHTO T119-74 except that during the course of construction control of concrete may be accomplished by the ball penetration as outlined in AASHTO T183-72. Two and a half (2.5) centimeter ball penetration is considered equivalent to a slump of five (5) centimeters.

The cement content shall be determined by means of a yield test in accordance with AASHTO T121-74.

310.3.4 Batching and Mixing

Concrete shall either be batched and mixed at a central batching and mixing plant or batched at a central batching plant for either mixing in field mixers adjacent to the forms for slabs, or mixed in a truck mixer. When cement is supplied in bags, each batch of concrete shall contain a whole number of bags of cement.

i) Batching Equipment

All aggregates and bulk cement for use in pavement shall be batched by weight by means of automatic devices of approved type conforming to the requirements specified below:-

The batching shall consist of dividing the aggregates into three sizes, each stored in a separate bin, of placing the cement in another bin, and of recombining these ingredients as herein provided.

Material discharged from the several bins shall be controlled by gates or by mechanical conveyors. The means of withdrawal from the several bins and of discharge from the weigh box shall be so interlocked that not more than one bin can discharge at a time; that the order of discharge can be changed as desired by the Engineer.; and that the weigh box cannot be tripped until the required quantity from each of the several bins has been deposited therein. Should a separate weigh box be used for each size of aggregate, all bins may be operated and discharged simultaneously. The discharge shall be so regulated that the amount of material discharged into the weigh hopper from any bin, with weighing devices at rest, will be within two (2) kg of the weight called for by the scale setting for the bin.

When the discharge from the several bins is controlled by gates, each gate shall automatically lock in an open or partially open position until the required weight is discharged into the weigh box, after which the gate shall automatically close and lock.

Scales utilized in the batching device may be of the spring less dial type or of the multiple beam type.

If they are the dial type, the dial shall be of such size and so arranged that it may be easily read from the ground. The automatic weighing device of the dial scale shall be so marked that the number of proportions required may be set on the dial at the same time and that proportions may be changed without delay.

If they are the multiple beam type, the separate beams shall be automatically connected to the hopper or weigh box in sequence. Multiple beam scales shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will be operated during the addition of the last seventy kilograms of any weighing. The over travel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust.

The beams or dial of automatic scales shall be so arranged that the weighing units will be in a compartment that may be locked at the requirement of the Engineer.

It is the intention of this Specification that the device shall be automatic to the extent that the only manual operation required for combining the ingredients for one batch shall be a single operation of a switch or a starter.

All receptacles used for weighing materials, together with the scales of any kind used in batching materials, shall be so insulated against the vibration or movement of the rest of the plant due to any operating equipment, that the error in weighing with the entire plant running will not exceed two per cent of any setting nor exceed one and a half per cent of any batch.

Should separate supplies of aggregate materials of the same size group, but of different moisture content, be available at the batching plant, withdrawals shall be made from one supply exclusively and the material therein completely exhausted before starting on another.

The moisture content of the aggregate shall be such that no visible separation of moisture and aggregate will take place during transportation from the batching plant to the point of mixing. Aggregates containing excess moisture shall be stockpiled prior to use until sufficiently dry to meet the above requirement.

Except where small quantities of concrete only are to be used, when the Engineer may permit otherwise, the equipment for batching of concrete materials shall conform to the following requirements:

The batching equipment shall be substantially constructed on a firm foundation, high enough above trucks being loaded to function properly. It shall have three (3) bins and a weighing hopper. The bins shall have a total capacity of not less than 100 tons, and the partitions between them shall extend not less than one (1) meter above the bins. The bins shall be equipped with baffle boards so as to assist drainage of the aggregates and prevent the drained out water from passing through the outlet gate. Al platform shall extend around the weighing hopper for easy means of inspection, adjustment and weighing.

The weighing hopper shall have a single compartment with arrangements for ready removal of excess material, and with a discharge gate opening parallel to the portion of receiving trucks. The amount of opening of the discharge gate shall be readily controlled. There shall be sufficient clearance at all points for the weighing hopper to function properly. The weighing scale shall be of the beam or springless dial type of standard design and make, and shall be able to record the true weight within two (2) kg at maximum load. The beam type shall have separate beams for each size of aggregate, and each beam shall have an easily operated locking device. A dial which will show the weight when the load is within forty five (45) kg of that required and an approved signal device shall be provided.

The weighing scales shall be arranged for ready standardization, and with each scale shall be furnished a set of standard weights including seven 25 kg, two 10 kg, two 5kg and two 2kg weights. For batchers of capacity of half (1/2) cubic meter or less, the standard weight to be furnished shall be as approved by the Engineer. The tolerance to these scales shall be within those listed in table 3 of the US national bureau of standard NBS handbook 44. The standard weights shall be protected against the defacement and injury, and shall be easily to handle and attached. All parts of the weighing devices and appurtenance of the batching equipment shall be substantially made and shall be maintained in proper operating condition. If in the opinion of the Engineer, any part or all of the weighing devices or other appurtenances are not satisfactory, they shall be replaced in satisfactory at the Contractor's expense.

In lieu of the automatic devices for controlling the weighing of the aggregates and bulk cement as described in the forgoing specification for batching equipment, the Contractor may be permitted to substitute manually controlled devices, provided approval for such devices is granted by the Engineer.

ii) Unloading and Hauling Equipment

Aggregate shall be transported from the batching plant to field paver mixers in batch boxes, vehicle bodies or other containers of adequate capacity and construction to carry the volume required, properly.

Partitions separating batches shall be adequate and effected to prevent spilling from one compartment to another while transit or being dumped. Where cement is stored in bulk, the contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to mixer, with chute, boot or other approved device, to prevent loss of cement and arranged to provide positive assurance of the actual presence in each batch of the entire cement specified.

Loose cement shall be transported to the mixer in waterproof compartments carrying the full amount of the cement required for the batch or it may be carried in compartments covered by the aggregate. Batches where cement is placed in contact with the aggregates may be rejected unless mixed within one and a half hours of such contact. Cement in originally shipping packages may be transported on top of the aggregates, each containing the number of bags required by the job mix.

Batches shall be delivered to mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss of cement, and when more than one batch is carried on the truck without spilling of material from one batch compartment into another.

iii) Batching to Central Mixing Plant

At a central mixing plant, batches shall be discharged from the weighing, hopper into the mixer either directly by gravity or by elevating container, large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from the weighing hopper to mixer drum.

iv) Field Mixing Equipment

The concrete mixer shall be a batch mixer so designed as to ensure positive, uniform distribution of materials throughout the mass. The size and type of mixer used on various classes of work shall be as specified below and shall be approved by the Engineer. For all work, where the volume of concrete to be placed justifies it, the mixer shall have a capacity of not less than one cubic meter, shall be of approved make and acceptable to the Engineer, and shall comply with the following requirements:

Mixers shall have a locking device preventing the mixture from being discharged before the expiration of the specified mixing time; an automatic locking device preventing materials being placed in the mixer before discharge gate is closed; a regulator that will maintain the rate of speed for which the mixer has been designed; a signal device that will function when water is added; a vertical water tank with an automatic device that will measure and discharge the required volume of water; valves to prevent overflow into the mixing chamber or on to the ground when the discharge valve is closed and into the tank when open; and valves and piping in proper order to prevent any leakage. The automatic device for measuring and discharging the required volume of water shall be arranged to discharge a predetermined volume, to be easily adjusted to discharge a larger or smaller volume, and to register the volume discharged accurately on a gauge or dial which shall be calibrated before the mixer is used and shall be kept properly calibrated. A by-pass valve shall permit the discharge of all the water into a measuring cane for the purpose of calibration. The measuring of the volume of water required shall be done by means of adjustable discharge device only.

The loading skip of the mixer shall be substantially made and shaped so that wet sand and other materials will not remain in it when it is being discharged. The mixer shall not

be used when any of the devices above stated are not functioning properly, or when the blades of the mixer have worn down to ninety (90) per cent of their original width. The Contractor shall furnish a certified statement from the manufacturer as to their original width. The mixer shall be kept clean and free from hardened mortar.

v) Truck Mixers

Truck mixers shall be used only when permitted by the Engineer in writing. Each transit mixer shall have a watertight drum, suitable mounted and fitted with adequate blades capable of properly combing the mixture. A batch meter and locking device to prevent discharge prior to completion of mixing shall be provided on each unit. Measuring tanks, equipped with outside taps and valves to facilitate checking their calibration, shall be provided for the mixing water. All water added to the mixer shall be passed through an approved water meter, located between the water tank and mixer drum, equipped with indicating dials and totaliser, and capable of measuring and discharging a specified amount of water within an accuracy of one per cent. The device shall provide means of readily verifying the amount of water added to mixing shall be provided on each mixer. An inspection opening shall be provided on each mixer, to permit ready determination of the consistency of the concrete being placed in the forms. When pick-up and throw over blades are worn down two (2) centimeter or more in depth, they shall be replaced with new blades. The Contractor shall furnish a certified statement from the manufacturer as to the original depth of the blades.

310.3.5 Placing Concrete

a) General

The mixer shall be operated outside of the forms at all times except at locations where the Engineer deems it not feasible to do so.

When ordered by the Engineer, the subgrade shall be moistened as directed, prior to the placement of the subgrade paper such as polythene sheeting.

Concrete mixed in central plant shall be transported without delay from the mixing plant to the position for laying and any concrete which in the opinion of Engineer has been mixed too long before reaching, the work will be rejected and shall be removed from the site. The concrete shall be deposited on the subgrade in successive batches for the full width between forms and in a manner which will require as little rehandling as possible. Spreading shall be done by an approved mechanical spreader in a manner that will prevent segregation and separation of the materials. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances. The amount of material deposited shall be sufficiently in excess of that required to form the pavement to the required cross-section after consolidation in order to provide a roll of concrete ahead of the front screed of the finishing machine for the full length of the screed.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all expansion joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade or a side form. In no case shall the vibrator be operated longer than fifteen (15) seconds. Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper on to a joint assembly. Damage to joint assemblies caused by dumped concrete shall be repaired immediately as directed by the Engineer at Contractor's expense. Trucks delivering concrete shall not run on polythene sheeting nor shall they run on completed slabs until at least fourteen (14) days after placing the concrete or until concrete has gained ninety (90) percent strength of specified 28 days cylinder crushing strength.

Should any concrete materials fall on or be worked into the surface of completed slab, they shall be removed immediately by methods approved by the Engineer.

Placement of concrete ahead of the initial spreader strike off shall not be more than fifteen (15) minutes ahead of final spreader strike-off. If concrete is placed in one (1) layer only, the placement of concrete shall not be more than twenty (20) minutes ahead of the spreader strike off.

In order to secure adequate compaction, the concrete is to be spread with a surcharge above the finished level of the layer. Spreading, compacting and finishing operations are to be completed without delay.

The total time taken from the addition of the water to the mix until the completion of the surface finishing operations shall not exceed thirty (30) minutes when the shade or mix temperature exceeds twenty seven (27) degree C or forty (40) minutes when less than twenty seven (27) deg. C. The mixing and placing of the concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The additives shall be added to the concrete mix so as to ensure more setting time. The top of the forms shall be kept free from accumulation of concrete or foreign material. The Contractor shall not permit the accumulation of laitance along the edge of a slab poured adjacent to one previously placed. Any accumulation of laitance shall be removed and replaced with fresh concrete. As soon as the side forms are removed, the edges of the slab shall first be inspected by the Engineer and any minor honey combed areas shall then be filled in with mortar composed of one part of cement to two parts of fine aggregate under the supervision of the Engineer.

b) Paving Equipment

Contractors shall use either slip-form or fixed-form paving methods, as approved by the Engineer, depending upon the nature of the placement. The mix design of concrete shall accordingly be prepared. The concrete mixtures required by either placement method vary significantly. Slip-form paving operations require a low-slump mixture that will not slough after extrusion by the paving machine, while a fixed-form paving operation relies on a higher slump mixture that will flow easily to fill the forms.

Slip-form paving is generally for placements requiring higher production rates, such as mainline paving. Fixed-form paving is adaptable to nearly any placement circumstance, but because it requires setting up side forms to hold the concrete, it is generally not as efficient. The main requirements for both types of equipment are tabulated in Table 310-3.

The paving train shall comprise of a combination of individual machines that place and finish concrete pavement. For highway applications, paving train shall include, but not limited to, the following:

- Spreader with belt placer.
- Slip-form paver.
- Texturing machine.
- Curing cart (usually together with the texturing unit).

Table 310-3: Requirements of Paving Machines

Sr. No.	Slip Form	Fixed Form
1	Self-propelled with either two or four tracks.	Ride on the forms or on self-propelled wheels.
2	Steering and elevation controlled from reference string lines.	Steering and elevation controlled by fixed forms.
3	Paving width: 4.0 m (Min.)	Paving width: 4.0 m (Min.)
4	Weight: about 3,000 kg or more per meter of paving lane width.	Weight: about 1,500 kg/m of paving width.
5	Continuous auger or hydraulic plow-pans to distribute concrete in front of the screed (may carry head of concrete in front of paver).	Suspended screw auger to spread concrete in front of screed or roller.
6	Contain variable speed hydraulically controlled internal vibrators, with optional vibration monitoring capabilities.	Have one or two vibrators that move transversely in front of the screed. May also use fixed vibrators near the form edges.
7	Provide the consolidation energy required for highway pavements as thick as 375 mm (15 in.).	Provide the consolidation energy required for pavements as thick as 250 mm (10 in.).
8	Allow for various finishing attachments.	

c) Weather Conditions

For concreting during hot/cold weather, requirements 401.3.6 (i) of these specifications will be followed. All construction work shall be carried out only in day light and no night time activity shall be allowed.

310.3.6 Placing Reinforcement

All pavement reinforcement shall be placed as shown on the plans. All marginal bars, dowel bars, and tie bars required by the plans shall be held in proper position by sufficient number of metal bar supports or pins as approved by the Engineer. If the center joint is to be sawed in lieu of placing the metal center strip, the tie bars may be installed mechanically by means of equipment and methods approved by the Engineer. The satisfactory placement of the tie bars shall depend upon the ability of the mechanical device to place the tie bars in their true position. The Engineer may require, when satisfactory placement is not obtained by mechanical means, that the tie bars be installed ahead of placing the concrete and that they be securely staked and tied if necessary to hold them in their exact position. The use of removable devices, supporting the bars from the forms, will not be permitted.

Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown

on the plans. When reinforced concrete pavement is placed in two (2) layers, the entire width of the bottom layer shall be struck-off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete after which the top layer of the concrete shall be placed, struck off and screeded. Any position of the bottom layer of the concrete which has been placed more than thirty (30) minutes with out being covered with the top layer shall be removed and replaced with freshly mixed concrete at the contractor's expense. Plain concrete and bar reinforced bridge approach pavement may be placed in one (1) layer.

Where two (2) layers of wire mesh reinforcement are required, as at bridge approaches, the bottom layer shall be supported in the required position with bar chairs. Separators shall be used for the top layer if the strike off cannot be properly used for the operation. Laps in adjustment sheets or mats of reinforcement shall be as shown on the plans. Laps parallel to the centerline of the pavement will not be permitted except for unusual widths of pavement lanes or for irregular areas. If the plans do not show dimensions for laps, the minimum lap either perpendicular or parallel of the centerline of the pavement shall be fifteen (15) centimeters. The adjacent sheets shall be fastened or tied together to hold all parts of the sheets in the same plane.

Reinforcing steel shall be free from detrimental amounts of dirt, oil, paint, grease, loose mill scale, and loose or thick rust which could impair bond of the steel with the concrete.

310.3.7 Joints

Joints shall be constructed exactly in accordance with the details shown on the plans and specifications and with the best of workmanship. Failure to construct the joints as called for and in the best possible manner, as determined by the Engineer, will be cause for suspension of work until the cause of the defective work is remedied.

If removal of existing pavement of any type is required to connect with the new pavement, and the termination of the removal is not at an existing joint, the new joint shall be made by sawing the existing pavement not less than five (5) centimeters deep before removal.

a) Expansion joints

The subgrade at Expansion joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement.

A string line shall be stretched between the pavement forms along the centerline of the joint. One half of the length of each dowel bar shall be painted in accordance with the directions shown on the plans and then thoroughly coated with hard grease, or lubricant as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel.

The entire joint assembly shall be of a type designated on the plans and shall be installed in such a position that the centerline of the joint assembly is perpendicular to the centerline of the pavement slab and the dowels lie parallel to the centerline of the slab. Finished joints shall not deviate more than six (6) millimeters in the horizontal alignment from a straight line. No plugs of concrete shall be permitted any where within the expansion space.

A slip sleeve of the dimensions shown on the plans shall be placed on the greased end of each dowel. The greased ends shall be free to slide in the dowel holder and shall extend in the direction as indicated on the plans. Any excess grease on the dowel holder shall be removed.

The joint shall be securely staked or fastened in place prior to placing the concrete and in a manner to ensure the joint and the dowel bars will remain in their proper position after the concreting and finishing operations are completed.

Joints for pavement designed for two (2) or less lanes of traffic shall be assembled and installed in one (1) continuous piece or the connections between sections shall be made rigid and tight to prevent offsets in sections of the joints. The length of individual pieces of the expansion joint filler shall be not less than the width of one (1) traffic lane of the pavement.

The finishing machine shall be operated in a manner that will prevent displacement of the joint. If for any reason it is necessary to straighten a joint, any depression caused by this operation shall immediately be filled with fresh concrete, respaded and brought to the original crown in advance of the longitudinal finishers. Any fluid laitance or mortar caused by this operation shall be removed and replaced with fresh concrete.

As the finishing machine approaches the joint on the first trip, the excess concrete shall be shoveled ahead and the tamper and each screed, in turn, shall be lifted over the joint. On the second trip of the finishing machine, the screed may be operated over the joint.

b) Contraction Joints

Contraction joints shall be of the type and dimensions and at the spacing shown on the plans. Sawed contraction joints shall be cut by means of an approved concrete saw. The joints shall not be sawed until the concrete has hardened to the extent that tearing and reveling is precluded. All joints shall be sawed during the initial curing period and the sawing shall begin before the pavement starts shrinking and before uncontrolled cracking takes place. Any procedure which results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing media and the cutting of the joints. In no case shall the pavement be left overnight without having the joints sawed. The joints shall be sawed at the depth, spacing, and lines shown on the plans. Guidelines or devices approved by the Engineer shall be provided to ensure cutting the joint in a straight line and perpendicular to the centerline of the pavement. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination of air and water applied under pressure immediately after the joint has been cut, and before filling with joint compound. When the plans specify that dowels be installed through contraction joints, the subgrade at the contraction joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement. A string line shall be stretched between the pavement forms along the center line of the joint. Each dowel shall be painted and thoroughly coated with hard grease or lubricant, in accordance with the direction shown on the plans or as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel. The entire joint assembly shall be of the type designated on the plans and shall be installed in such a position that the centerline of the joint assembly is perpendicular to the center line of the slab and the dowels lie parallel to the slab surface and parallel to the centerline of the slab. The greased ends of the dowels shall be placed in the direction as indicated on the plans and shall be free to slide in the dowel holder. Any excess hard grease on the dowel holder shall be removed.

c) Longitudinal Joints

Longitudinal joints shall be constructed in conformance with the details shown on the plans. When the fabricated steel strip is specified, it shall be held rigidly in place with an adequate number of pins driven into the subgrade to ensure that it will remain true to line and grade during concreting and finishing operations. On multiple lane pavement where longitudinal joints are constructed at the form line, an approved recessed form

and tie bars will be required. The full depth fabricated steel strip designated for other longitudinal joints will not be permitted. When sawed joints are specified or used, suitable guidelines or devices shall be furnished to ensure cutting the longitudinal joint on the true lines as shown on the plans. The sawing of longitudinal joints shall be performed at a time that will preclude erratic or uncontrolled cracking. Sawed joints shall be filled with the type of joint compound indicated on the plans. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of air jet or a combination of air and water applied under pressure immediately after the joint has been cut and before filling with joint compound.

d) Construction Joints

A butt construction joint shall be made perpendicular to the centerline of the pavement at the close of each days work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete will have taken its initial set. This joint shall be formed by using a clean plank header having a nominal thickness of five (5) centimeters, a width of not less than the thickness of the pavement and a length of not less than the width of the pavement. The header shall be cut true to the crown of the finished pavement and shall be accurately set and held in place in a plane at right angles to centerline and perpendicular to the surface of the pavement.

The top surface of the header shall be protected with steel as approved by the Engineer. On the face along with the center of the header there shall be fastened a trapezoidal piece of metal or wood the full length of the header, five (5) centimeters wide and at least twenty five (25) millimeters in depth to form a grooved joint. The header shall have drilled holes to accommodate the dowel or tie bars hereinafter specified. Upon resumption of Work any surplus concrete remaining upon the subgrade shall be removed. The header shall then be carefully removed and fresh concrete deposited against the old in such a manner as to avoid injury to the edge of the old concrete. The fresh concrete shall be vibrated into the groove in a manner to ensure an interlocking joint.

Dowel bars or load transfer devices shall be used in all construction joints in accordance with the details shown on the plans. If no such details are shown on the plans, tie bars as provided for the longitudinal joint, and spaced at forty-five (45) centimeter centers, shall be placed across the joint in a plane parallel to the surface of the pavement approximately midway between the top and bottom surfaces of the pavement. The edges of the joint shall be grooved, edged, and sealed with the material used for sealing expansion and contraction joints.

No construction joint shall be placed within three (3) meters of an expansion, contraction, or other construction joint.

e) Joints Around Structures

Expansion joints shall be made between the surface layer and any structures on the road such as lighting posts bases or traffic signals or any other structures such as bridges. The joints shall be executed according to the type, dimensions and sites shown on the drawings. It is not permissible to use any reinforcement bars binding between the surface layer and road structures. The joints shall be filled with the suitable fill materials according to what is practiced with expansion joints.

f) Sealing Joints

i. **Materials**: Joints shall be sealed with material of the type designated on the plans.

ii. **Hot Poured Joints**: The joints shall be sawed as provided in sub item 310.3.7(b) and covered as provided in sub item 310.3.7(c). After the fourteen (14) or seventeen (17) day curing period for the pavement has elapsed, the jute or other protective covering shall be removed from the joint and the joint thoroughly cleaned of all loose scale, saw dust, dirt, laitance or other matter. Cleaning may be accomplished with a compressed air jet, air and water under pressure, wire brushes or in extreme cases the joint shall, when directed by the Engineer, be re-sawed to ensure a completely clean joint. The joint surfaces and adjacent areas of the slab shall be thoroughly clean.

The hot poured joint material shall be heated in a heating unit approved by the Engineer to the temperature within the range required as shown by tests. The joint shall be filled from the bottom of the saw cut to the surface of the pavement. Any joint with a depth greater than twenty five (25) millimeters shall be filled with a minimum of two (2) layers, each layer being approximately equal in depth.

iii. **Cold Poured Joints**: The joints shall be sawed as provided in sub-item 310.3.7(b) & 310.3.7(c) and cleaned of all loose saw dust, laitance, dirt, other foreign matter and free water.

The joints shall be filled immediately after cleaning. The nozzle used must be so designed that the joint is filled completely from bottom to top. The joint shall be filled so it is rounded on top about six (6) millimeters above the pavement surface. Immediately after the joints have been filled, they shall be covered with strip of non-absorptive paper at least four (4) centimeters wide. Eleven (11) kilogram glassline or heavy craft is suitable. The paper shall remain on the joint until it weathers or wears off.

iv. **Premoulded Neoprene Seal**: The joints shall be sawed as provided in sub-item 310.3.7(b) & 310.3.7(c) and cleaned of all loose saw dust, laitance, dirt, other foreign matter and free water.

The installation machine should be capable of installing the seal at the specified depth without cutting, nicking or twisting the seal. The installation machine will be self propelled and also must be capable of installing the seal with 4% or less stretch. Hand installation is not acceptable as the primary installation method.

The lubricant-adhesive meeting ASTM D-2835 is used mainly to facilitate the installation of the Preformed Neoprene seal. The lubricant-adhesive must contain a minimum of 22% solids, be uniform, contain no lumps, have the correct viscosity and have a drying time between eight and twenty minutes. The containers of lubricant-adhesive should be labeled with the manufacturer's name, catalog number, lot number and manufacture date. Also, Safety Instructions must accompany all shipments for the safety of the user. The lubricant-adhesive will begin to thicken at 32°F. When sealing operations occur where the air temperature is below 32°F, the lubricant-adhesive must be stored in a heated warehouse until immediately prior to use.

The proper installation sequence for preformed neoprene compression seals is to install the longitudinal seal first. After allowing the glue to dry (approximately 20 minutes), the longitudinal seal is cut with a sharp instrument or saw blade at the middle of the intersection of the transverse joint. Initially, only make one single cut. The material should retract, leaving

enough room for the transverse sealant. The transverse joint seal is then installed through the cut in the longitudinal seal to form a tight intersection. The transverse seal should be installed in one continuous piece. The transverse seal will exert outward force on the end cut of the longitudinal seal to form a tight intersection.

g) Permanent Header Board

Immediately after the forms are removed from the ends of concrete pavement that will be exposed to other than permanent type surfacing and temporary and permanent traffic, a header board having dimensions of not less than eight (8) centimeters (nominal) by twenty (20) centimeters shall be bolted securely to the end of the pavement in a manner to protect the edge of the pavement from damage. The header board shall extend the full roadway width, but may be in two (2) sections. At the time of placing the concrete , six (6) (three for each lane), thirteen (13) millimeters by twenty (20) centimeters bolts shall be embedded in the end of the pavement in a manner that will hold the header board securely. The header board shall be shaped to conform to the crown of the pavement and shall be installed flush with the concrete pavement surface. The finishing and installing of the header board shall be considered subsidiary Work pertaining to the other items in the Bill of Quantities and will not be paid for directly.

The header will not be required on concrete base course Work.

310.3.8 Consolidating and Finishing

After being spread and struck-off as provided in sub-item 310.3.5 "Placing Concrete," the concrete shall be further struck-off and consolidated with an approved finishing machine to such an elevation that when finishing operations are completed, the surface will conform to the required grade and crown. The finishing machine shall operate over the entire surface at least twice, the first time with the finishing machine tamper and both screeds in operation. A uniform roll of concrete approximately fifteen (15) centimeters above the pavement grade shall be maintained ahead of the front screed for its entire length during the first trip over with the finishing machine. Excessive tamping or finishing resulting in bringing an excess of mortar to the surface will not be permitted.

After the last pass of the finishing machine, a mechanical longitudinal finisher shall be operated over the concrete surface. The forward motion of the longitudinal finisher shall be so adjusted that the screed will pass over each portion of the surface at least twice. The longitudinal finisher shall be operated in a manner that will prevent excessive slumping of the concrete at the form lines or the metal center strip or the loss of the crown of the pavement. If necessary or when ordered by the Engineer, the finisher shall be operated in one direction only or shall be operated from only the form to the centerline in order to ensure that the proper cross section of the pavement is obtained. The leading edge of the screed shall clear the forms upon completion of each transverse pass in order to clear the pavement surface of any laitance or thin mortar.

In general, the addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted by the Engineer, it shall be applied as a fog spray by means of approved spray equipment.

As an alternative to the longitudinal finisher, the contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by four (4) or more visible wheels riding on, and constantly in contact with, the side forms.

When directed by the Engineer, following one of the preceding methods of longitudinal finishing, long-handled floats having blades not less than one and one half (1.5) meters in length and fifteen (15) centimeters in width shall be used to smooth and fill in open-textured areas in the pavement, Long-handled floats shall not be used to float the entire

surface of the pavement in lieu of, or supplementing, one of the preceding methods of longitudinal finishing.

When the longitudinal finishing has been completed, the entire surface shall be tested with straightedges not less than three (3) meters in length. The straightedges shall be operated parallel to the pavement centerline starting at the center and progressing toward the forms. Advance along the pavement shall be in successive stages of not more than one half (1/2) the length of the straightedges. All laitance, surplus water, and inert material shall be removed from the surface. All high places shall be worked down and all low places filled by combined operations of floats and straight edges until no irregularities exist. The proper crown of the pavement shall be maintained throughout the operations.

After floating and straightening has been completed, the concrete shall be finished by using a belt made of canvas, rubber, or other approved belting not less than fifteen (15) centimeters in width, nor less than sixty (60) centimeters longer than the width of the pavement. This belt shall be worked with a longitudinal and crosswise motion. Care shall be exercised in the use of the belt to ensure that the edges of the belt do not dig into the surface of the concrete or work the crown out of the pavement. Either machine belting or hand belting will be permitted.

As soon as all excess moisture has disappeared, and while the concrete is still plastic enough to make a granular surface possible, a drag shall be used which shall consist of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform surface of gritty texture after dragging it longitudinally along the full width of pavement. For pavement (5) meters or more in width, the drag shall be such that a strip or burlap or fabric at least one and one half (1.5) meters wide is in contact with the full width of pavement surface while the drag is used. The drag shall be maintained in such condition that the resulting surface is of uniform appearance and reasonably free from grooves over two (2) millimeters in depth, as determined by the Engineer. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags substituted.

After dragging the surface with burlap, the concrete over the expansion joint filler shall be completely removed and the joint finished. The edges of the concrete at expansion joints shall be finished with an edger to the radius shown on the plans. The exposed edge of the pavement shall be finished with an edger to a radius of six (6) millimeters. Any tool marks appearing on the slab adjacent to the joints or edge of slab shall be eliminated by dragging the surface. In doing this, the rounding of the corner of the slab shall not be disturbed.

Slip-From Paving

If Slip-form paving is used, a pad of well-compacted base material shall extend 1 m past the outside edge of the pavement. It shall be durable enough to provide for smooth passage of the entire paving train, including any texturing and curing equipment. If edge-drains are used, they shall be installed after paving so that the paving train will not crush them. The pad line shall be carefully maintained and kept free of debris.

The grades and lines of final paving surface shall be maintained by string lines. They shall be attached to rigid stakes and shall be stretched tightly enough to eliminate appreciable sagging. The stakes shall be at no more than 8 m intervals, and closer for horizontal and vertical curves. Alternatively, a GPS equipped paver may be employed to eliminate the use of string lines.

Paver vibrators shall be operated at a frequency from 5,000 to 8,000 vibrations per minute, at paver speeds greater than One (1.0) meter per minute. Vibrator frequency shall be lowered if paver speed falls below 1.0 m per minute. The vibrators shall be spaced horizontally so that the zones of influence of the adjacent vibrators overlap by 50–75 mm.

Concrete Pavement Slump

If Slip-from equipment is used for paving, the concrete behind the paver after laying shall not show top edge slump of more than six (6) mm. If slump is more than 6 mm, corrective measures shall be taken to rework the edge to remove the irregularity. If top edge slump is continuously more than 6 mm, paving operations hall be stopped and necessary corrective measures shall be taken to limit the excessive slump.

If bottom edge slump occurs during paving operations, construction shall be immediately stopped. This type of slump indicates an inconsistent mix design pertaining to slip-form. Corrective measures shall be taken with mix design so that bottom edge slump does not occur.

310.3.8.1 Hand Finishing

Unless otherwise specified, hand finishing methods will not be permitted except under the following conditions:

i). In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs, and no additional concrete shall be placed until such equipment is repaired to the satisfaction of the Engineer.

ii) Narrow widths or areas of irregular dimensions where operation of mechanical equipment is impractical as determined by the Engineer, may be finished by approved hand methods.

iii) Short lengths of pavement, such as bridge approach pavement, where the operation of mechanical equipment is impractical may be finished by approved hand methods.

Concrete, as soon as placed, shall be struck-off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete if reinforcement is used.

The screed for the surface shall be at least one (1) meter longer than the maximum width of the slab to be struck-off. It shall be of approved design, sufficiently rigid to retain its shape, and be constructed either of metal or other suitable material shod with metal.

Consolidation shall be attained by the use of a suitable vibrator or other approved equipment.

In operation the screed shall be moved forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

After the concrete has been struck-off, it shall be further smoothed, trued, and consolidated by means of a longitudinal float. The hand operated longitudinal float shall be not less than three and one-half (3.5) meters in length and fifteen (15) centimeters in width, properly stiffened to prevent flexing and warping. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the

concrete, shall be worked with a sawing motion, while held in a floating position parallel to the road centerline, and passing gradually from one side of the pavement to the other, Movement ahead along the centerline of the pavement shall be in successive advances of not more than one half (1/2) the length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass.

At the option of the Engineer, the long-handled floats having blades not less than one and one half (1.5) meters in length and fifteen (15) centimeters in width may be substituted for the hand operated longitudinal float.

All other operations after this substitution for the mechanical equipment shall be performed in the manner previously described.

310.3.9 Removing Forms

Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least twelve (12) hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as specified for the surface. Major honeycombed areas will be considered as defective work and shall be removed and replaced at the Contractor's expense, as directed by the Engineer.

Any area or section so removed shall not be less than three (3) meters in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) meters in length, shall also be removed and replaced.

310.3.10 Protecting and Curing of Concrete Pavement

a) Initial Curing

As the surface of the newly-laid pavement is progressively finished, the initial curing and protection operations shall be started.

Upon completion the finishing operation and while the surface of concrete is still moist, but no free water remains, a liquid curing membrane conforming to AASHTO M-148 shall be applied to the exposed surface of the pavement with mechanical pressure distributors at the following minimum rates:

- 5.0 sq. meters per Liter for normal paving applications.
- 3.75 sq. meters per Liter for fast-track concrete.
- 2.5 sq. meters per Liter for thin overlays.

The initial application of curing compound shall coat both the top and edges of slip-formed concrete.

The curing membrane, except on irregular areas, shall be applied by means of approved self-propelled mechanical pressure distributors or approved hand sprays. Satisfactory means shall be provided for thoroughly mixing the curing membrane compound before and during its use. The mechanical spraying equipment may be either a full width spray bar equipped with multiple nozzles or a traversing spray which travels from one edge of the pavement to the other. In either case the path of adjacent nozzles or passes of the traversing spray shall overlap a minimum of one-half (1/2) the width of the spray pattern so that all portions of the surface shall receive double applications from adjacent nozzles or passes. The pumping, pressure and distribution arrangement shall be correlated with the forward speed to provide adequate and uniform coverage of the pavement at not less than the minimum rate required. Irregular areas to which the mechanical distributor cannot be adapted may be covered with hand sprays.

When hand sprays are used, the curing membrane shall be applied in two (2) applications, each at a rate of not less than one (1) litre per five (5) square meters of surface area so as to provide a total rate of application of one (1) litre per two and one half (2-1/2) square meters of surface area. The path of the spray on the second application shall be at right angles to the path of the spray on the first application. When hand operated sprays are permitted, the equipment supplying the pressure to the spray nozzle shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane compound at the rate required. If from any cause, such as rain-fall soon after its application, the curing membrane is damaged, the Contractor shall immediately apply another application of

curing membrane to the surface of the pavement. The rate of application for the replacement membrane shall be the same as for the original membrane.

Unless otherwise directed by the Engineer, immediately following the application of the curing membrane, an approved shade-canvas shall be placed approximately thirty (30) centimeters above the pavement surface. The shade-canvas shall be constructed of materials and in a manner approved by the Engineer.

In no case shall any portion of the shade-canvas come in contact with the pavement. The initial curing shall be continued for a period of twenty four (24) hours from the time the curing membrane is applied.

When forms are removed, whether during the initial or the final curing period, the edges of the pavement shall receive curing membrane at the rate of coverage specified for the pavement surface.

The curing membrane may be applied to the vertical edges of the pavement by means of hand sprays or by nozzles attached to the mechanical distributor, but the edges of the pavement shall be covered with curing membrane at the rate specified within thirty (30) minutes after removal of the forms.

When cold-poured joint compound is used, all joints shall be sawed during the initial curing period. The shade-canvas may be moved at joint locations for short periods of time to permit the sawing. Before being sealed, the joints shall be thoroughly cleaned of all loose saw dust, laitance, dirt, other foreign matter, and free of water. As the method of final curing is different from that of the initial curing, the cleaning and sealing of joints shall be performed immediately following the removal of the shade-canvas at the end of the initial curing period and prior to the application of the polyethylene sheeting.

When hot poured joint compound is used, the joints shall be sawed, cleaned, and filled with jute or other acceptable protective material in the same time sequence as for cold-poured joints.

In no case shall any portion of the concrete pavement be exposed to the direct rays of the sun for more than one (1) hour.

Following jointing operations, curing membrane shall be applied to the joint area at the rate specified for the pavement surface.

b) Final Curing

Upon completion of the initial curing period and after the shade-canvas has been removed and jointing operation has been completed, the pavement shall be completely covered with White Opaque Polyethylene Film as specified in AASHTO M-171. Adjoining sheets shall be lapped a minimum of forty five (45) centimeters. The sheeting shall be held in place in a manner approved by the Engineer.

Final curing shall be continued until the concrete reaches an age of fourteen (14) days. During this period, the curing membrane and polyethylene film shall be protected from damage from any cause. Any damage from one cause shall be immediately repaired by the Contractor at his expense. No traffic, including workmen and pedestrians, shall be allowed on the surface of the pavement until the expiration of the fourteen (14) day curing period.

When concrete is being placed during the time that the air temperature may be expected to drop below fifteen (15) degrees C, a sufficient supply of burlap, straw, hay, or other suitable blanketing material shall be provided along the work to protect the concrete and maintain a minimum temperature of fifteen (15) degrees C in the concrete as measured on the surface of the pavement. An approved moisture barrier such as wet burlap or plastic sheeting shall be placed on the concrete prior to placing the blanketing material. This type of cure shall be maintained for a period of seventy two

(72) hours as the initial cure. After the initial cure as specified above, a final cure as specified above may be used. The final cure shall be maintained for a period of fourteen (14) days, thus making a seventeen (17) day curing period for cold weather concreting.

310.3.11 Surface Tolerance

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a three (3) meter straightedge or other specified devices. Areas showing high spots of more than three (3) millimeters, but not exceeding twelve (12) millimeters in three (3) meters between any two contact points, shall be marked and immediately ground down with an approved grinding tool to a tolerance of less than three (3) mm as described above. Where the departure from correct cross section exceeds twelve (12) millimeters, the pavement shall be removed and replaced by and at the expense of the Contractor.

Any area or section so removed shall be not less than three (3) meters in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) meters in length, shall also be removed and replaced at the Contractor's expense.

310.3.12 Tests for Thickness of Pavement and Degree of Compaction

i) Thickness of Pavement

The Employer will not be liable for payment of any excess in thickness of depth of pavement. During the progress of the work, the thickness or depth of pavement will be determined by the Engineer from cores cut from the concrete pavement by the Contractor. The cost of cutting and recovering all the cores described in this clause and the following paragraph shall be deemed to be included in the rates and prices for Portland Cement Concrete Pavement entered by the Contractor in the Bill of Quantities.

Unsatisfactory work shall be repaired, replaced, or will be paid for at an adjusted price, as follows:

a) One 15cm diameter core will be removed by the Contractor from each lane, at such locations as the Engineer may direct, and shall represent not more than 1000 SM of pavement area. A lane shall be considered the pavement surface between longitudinal joints, or a longitudinal joint and pavement edge.

b) If any core measurement is deficient more than 6.5 mm from the required thickness a core measurement shall be taken at each 30m interval in both directions longitudinal from the first deficient core in the same lane, as defined herein, until the thickness of the pavement is found to be not more than 6.5 mm deficient from the required thickness. Each deficient core shall be considered as representing the condition in the same lane or longitudinal section, as above defined, for a distance of 15m, in each direction longitudinally from the core.

c) Sections of pavement which are deficient in thickness, as determined by cores, by an amount more than 1.3 cm shall be removed and replaced with pavement of the specified thickness at the expense of the Contractor. The removal and replacement shall start at the determined point of deficiency and proceed longitudinally as hereinafter specified, until the pavement is to be not more than 6.5 mm deficient from the required thickness. The old reinforcing steel shall be left extended a sufficient distance so as to allow the new reinforcement steel to be lapped with the old, the required distance to be welded to the satisfaction of the Engineer.

d) The removal and replacements of pavements shall extend transversely the full width each lane in which such deficiency is found.

e) All pavements within two (2) meters of the deficiency spot shall be removed, except that when any joint is more than two (2) meters, all pavements shall then be removed to the next joint.

f) Sections of pavement which are deficient in thickness, as determined by measurement of cores in accordance with AASHTO T148-49, by an amount more than 6.5 mm, but not more than 1.3 cm, will be paid for at an adjusted price as specified in Table below:

Table 310-4: Deficiency in Thickness as Determined from Cores

Thickness	Proportional Part of Contract of Contract Price to be allowed.
3.00 mm to 6.5 mm	95 %
6.5 mm to 13 mm	75 %

ii) Degree of Compaction

The cores that have been cut from the concrete pavement according to the requirements of (i) above shall be examined by the Engineer's Representative to check the degree of compaction achieved through the slab and to check the effectiveness of the bond between the top and bottom course concrete.

Should any core reveal that any part of the slab has not been adequately compacted by revealing honeycombed or segregated concrete and should the bond between the top and bottom layers of concrete be such that a plane of weakness is present, then additional cores shall be taken to check the areas of defective concrete pavement according to the procedure laid down in (i) above for determining the areas of concrete pavement deficient in compaction.

Any areas of defective pavement concrete so found shall be replaced with new concrete in accordance with this section at contractor's own expense.

The Engineer reserves the right to carry out crushing tests on any or all of the concrete cores taken in accordance with this clause, and should these tests show that any area of pavement concrete has failed to meet the strength requirements of the specification, then such areas of concrete shall be removed and replaced with new concrete, mixed, laid, compacted and finished to the requirements of this section at contractor's own expense.

iii) Refilling of Holes

Holes in the pavement created by the cutting of cores shall be thoroughly coated on the inside with a neat cement grout and shall then be filled with concrete of the same mix as shown in the pavement. The filling shall be in two equal layers and each shall be rodded 25 times to its full depth. The surface shall be finished flush and broomed. The surface shall be kept thoroughly wet for 72 hours thereafter.

310.3.13 Replacement of Defective Concrete

Any concrete not complying with the specification shall be cut out and replaced in accordance with the specification over the full width of the slab between longitudinal construction joints and over a length extending between two transverse joints each of a type other than a warping joint.

310.3.14 Concrete Lug Anchors

"Concrete Lug Anchors" shall be constructed in accordance with the dimensions and notes and at the locations shown on the plans. Unless otherwise indicated on the plans, the class, composition, consistency, proportioning, batching, mixing and curing of the concrete used in concrete lug anchors shall conform to the same requirements as the concrete pavement. Reinforcing steel, concrete and excavation for lug anchors shall be subsidiary to the Bill of Quantities item "Concrete Lug Anchors."

310.4 MEASUREMENT AND PAYMENT

310.4.1 Measurement

The unit of measurement for payment shall be the cubic meters of the completed and accepted Portland Cement Concrete Pavement, as measured in place. The number of cubic meters of the completed Portland Cement Concrete Pavement shall be determined by the length measured along the centre line and upon the surface of the road, times the width as shown on the Drawings plus the areas of any widening on curves, turnouts and intersection, authorized and measured separately. Measurement of pavement thickness will be ensured by erecting shutters for screeding concrete at required level.

The unit of measurement for bridge Approach Slabs shall be the cubic meters of the area actually constructed in accordance with the Drawings or as directed in writing by the Engineer.

Concrete Lug Anchors shall be measured by the linear meters in place, the measuring being made along the centerline of the concrete lug anchor transverse to the pavement centerline. No measurement will be made of unauthorized areas or for extra thickness.

310.4.2 Payment

The number of cubic meters of Portland Cement Concrete Pavement, measured as specified in sub-item 310.4.1 above, will be paid for, at the price tendered per cubic meter in the Bill of Quantities, adjusted as specified for deficiency in thickness, which price shall include the cost of constructing, finishing, curing, protecting and cleaning the pavement as above described; the preparation of subgrade to receive the pavement; the construction of all joints of whatever type; cutting of cores and filling of holes, all materials, including backing rod, joint sealer and other material, equipment, labour and all else necessary thereof, and all other work in connection therewith and incidental there to in accordance with the specification and Drawings. Reinforcing steel shall be measured separately under relative items of work.

The number of cubic meters of Bridge Approach Slabs, will be paid for at the price tendered per cubic meter in the Bill of Quantities, which price shall include the cost of constructing, finishing, curing, protecting and cleaning the slab as above described; the surface preparation of the sub-base to receive the slab; the construction of all joints of whatever type; all materials, including joint filler and other joint material, equipment, labour and all else necessary thereof, and all other work in connection therewith and incidental thereto in accordance with the Specification and Drawings.

SECTION 311 PROOF ROLLING

311.1 DESCRIPTION

The work shall consist of conducting proof rolling by a specified type of roller to confirm the adequacy of compaction for the underlying layers of an existing road or natural surface. The proof rolling shall be carried out in accordance with these Specifications and in conformation with the lines shown on the drawings or as directed by the Engineer.

311.2 CONSTRUCTION REQUIREMENTS

1. The proof rolling is to be carried out on any type of granular material, subgrade material or asphaltic layers as the case may be. However, in case, the proof rolling is to be carried out on granular material / subgrade, all the undulations shall be removed by the contractor as a pre-requisite of this item for which payment shall be deemed to be included within this item.

2. The equipment required for compaction may be any of the following or combination there of:

   a. Combination vibratory roller – min. 10 tons capacity.

   b. Pad foot vibratory roller – min. 10 tons capacity.

   c. Pneumatic type roller, 9 wheeler – 21 tons capacity.

311.3 MEASUREMENT AND PAYMENT

311.3.1 Measurement

Proof rolling shall be measured by the unit of square meter in the areas as designated on the drawings or directed by the Engineer.

311.3.2 Payment

The quantity of completed and accepted work, measured as provided above will be paid at the unit price quoted by the contractor for furnishing all equipments,. Labour, and other items necessary for the completion of the work.

Pay Item No.	Description	Unit of Measurement
311	Proof Rolling	SM

SECTION 312 EMULSIFIED ASPHALT / TST APPLICATIONS

312.1 DESCRIPTION

This work shall consist of material and construction requirements for various applications of emulsified asphalt as specified under this Item and in conformity with the lines, grades and typical cross-sections shown in the drawings or as directed by the Engineer. Emulsified Asphalt and its applications shall conform to Asphalt Institute MS No.19 (Third Edition or later). Guidance shall be taken from other relevant sections of specifications for activities and material not covered under this item.
This item shall consist of one or more of the following items as mentioned in the Bill of Quantities.

a) Single Surface Treatment (with Emulsified Asphalt)
b) Double surface Treatment (with Emulsified Asphalt)
c) Triple Surface Treatment (with Emulsified Asphalt)
d) Sand Seal
e) Slurry Seal
f) Micro Surfacing
g) Emulsion Aggregate Mix

312.2 MATERIAL REQUIREMENTS

312.2.1 Emulsion Ingredients

Emulsified Asphalt shall consist of three main constituents: asphalt, water, and emulsifier. Emulsified Asphalt shall conform to the relevant sections of Item 301 in addition to the following requirements and those listed in Tables 313-1 and 313-2.

312.2.1.1 Asphalt

Emulsified asphaltic material shall conform to the relevant requirements listed in Tables 313-1 and 313-2 for each type of asphalt. Emulsified asphalt shall be obtained from a manufacturer approved by the Engineer. Emulsified asphalt shall be delivered at site in sealed containers and stored in an appropriate manner as per requirements of the manufacturer.

312.2.1.2 Water

Water with presence of appropriate ions suitable to the requirements of cationic or anionic emulsions shall be used to ensure stability of the emulsion. Natural water shall not be used unless it is treated to comply with the requirements of the emulsion.

Water containing particulate matter shall not be used in emulsion production. The use of impure water may result in an imbalance of the emulsion components that can adversely affect performance or cause premature breaking.

Water for construction activities shall be suitable for the particular activity and compatible with other materials.

312.2.1.3 Emulsifying Agents

Asphalt emulsion properties greatly depend on the chemical used as the emulsifier. The emulsifier is a surface active agent, or a surfactant. The emulsifier keeps the asphalt droplets in stable suspension and controls the breaking time. It is also the determining factor in the classification of the emulsion as anionic, cationic, or nonionic.

Basically, there are three types of surfactants that are classified according to their dissociation characteristics in water:

(1) **Anionic Surfactants -** Where the electrovalent and polar hydrocarbon group is part of the negatively charged ion, when the compound ionizes:

ANIONIC $CH_3(CH_2)_n\ COO^-\ Na^+$

(2) **Nonionic Surfactants -** Where the hydrophilic group is covalent and polar, and which dissolves without ionization:

NONIONIC $CH_3(CH_2)_n\ COO\ (CH_2CH_20)_x\ H$

(3) **Cationic Surfactants** - Where the electrovalent and polar hydrocarbon group is part of the positively charged ion when the compound ionizes.

CATIONIC $CH_3(CH_2)_n\ NH_3^+\ Cl^-$

To be an effective emulsifier for asphalt, surfactant shall be water soluble and possess a proper balance between the hydrophilic and lipophilic properties.

312.2.1.4 Aggregates

Aggregates shall be crushed and shall have cubical shape. Aggregates shall meet all the requirements as listed in Article 305.2.1 of this specification, in addition to the requirements listed under each type of application.

The aggregates shall also meet the requirements for size, shape and cleanliness as per the type of application. The aggregates shall not be dusty or coated with clay, silt or any other contaminant which may hinder bond of emulsion with the aggregates.

Mineral filler may be used to improve mixture consistency and to adjust mixture breaking and curing properties. Portland cement, hydrated lime, limestone dust, fly ash, or other approved filler meeting the requirements of ASTM D 242 shall be used if required by the mix design. Typical use levels are normally 0.0 - 3.0 percent and may be considered part of the aggregate gradation.

312.2.1.4 Additives

Additives may be used to accelerate or retard the break/set in emulsified asphalt applications. Appropriate additives, and their applicable use range, shall be approved by the Engineer prior to use at site, as part of the mix design based on laboratory testing.

312.3 CONSTRUCTION REQUIREMENTS

312.3.1 Testing

The Asphalt Emulsion shall meet the requirements laid out in the following tests. Tests on emulsified asphalts shall be performed under ASTM D-977 and ASTM D-2397 for anionic and cationic emulsions respectively. For standard test methods and practices, ASTM designation D 244 shall be followed. Reference values for each test are listed in tables 313-1 and 313-2.

312.3.1.1 Emulsion Viscosity

Viscosity is defined as fluid's resistance to flow. For asphalt emulsions, the Saybolt Furol viscosity test shall be used as a measure of viscosity. Results shall be reported in Saybolt Furol seconds. Depending on the type of emulsion, one of two testing temperatures are used, 25°C and 50°C (77°F and 122°F).

312.3.1.2 Demulsibility

The demulsibility test indicates the relative rate at which the colloidal asphalt globules in the rapid-setting asphalt emulsion will break when spread in thin films on soil or aggregate. Rapid setting emulsions are expected to break almost immediately upon contact with aggregate, such as when chip sealing.

312.3.1.3 Settlement and Storage Stability Tests

These tests indicate the emulsion's stability in storage. They also detect the tendency of globules to settle over a period of time.

312.3.1.4 Sieve Test

The sieve test is another measurement of quality and stability of the emulsion. The retention of an excessive amount of asphalt particles on a sieve indicates that problems may occur in the handling and application of the material.

312.3.1.5 Unit Weight of Asphalt Emulsion

The unit weight (kg/liter or lb/gallon) is computed by finding the weight of an asphalt emulsion in a standard measure of known volume. Results shall be reported to the nearest whole unit in gram per liter (g/L) at 25^{o}C.

312.3.1.6 Residue and Oil Distillate by Distillation

Distillation is used to separate the water from the asphalt. If the material contains oil, it will be separated along-with the water. The relative proportions of asphalt cement, water and oil in the emulsion can be measured after the distillation has finished. Additional tests may be run on the asphalt cement residue to determine the physical properties of the end-use asphalt.

TABLE 312-1: Requirements for Emulsified Asphalt

NOTE 1—QS-1H emulsions shall meet the requirements outlined in Practices D 3910.
NOTE 2—QS-1h is used for Quick Set Slurry Seal systems.

Type	Rapid Setting						Medium Setting						
Grade	RS-1		RS-2		HFRS-2		MS-1		MS-2		MS-2h		
	min	max	min	Max	Min	max	min	max	min	max	min	max	
Tests on emulsions													
Viscosity, Saybolt Furol at 25°C (77°F), SFS	20	100	…	…	…	…	20	100	100	…	100	…	
Viscosity, Saybolt Furol at 50°C (122°F), SFS	…	…	75	400	75	400	…	…	…	…	…	…	
Storage stability test, 24-h, %	…	1	…	1	…	1	…	1	…	1	…	1	
Demulsibility, 35 ml, 0.02 N CaCl2, %	60	…	60	…	60	…	…	…	…	…	…	…	
Coating ability and water resistance:													
Coating, dry aggregate	…		…		…		good		good		good		
Coating, after spraying	…		…		…		fair		fair		fair		
Coating, wet aggregate	…		…		…		fair		fair		fair		
Coating, after spraying	…		…		…		fair		fair		fair		
Cement mixing test, %	…	…	…	…	…	…	…	…	…	…	…	…	
Sieve test, %	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10	
Residue by distillation, %	55	…	63	…	63	..	55	…	65	…	65	…	
Oil distillate by volume of emulsion,%	…	…	…	…	…	…	…	…	…	…	…	…	
Tests on residue from distillation test:													
Penetration, 25°C (77°F), 100g, 5 s	100	200	100	200	100	200	100	200	100	200	40	90	
Ductility, 25°C (77°F) 5 cm/min, cm	40	…	40	…	40	…	40	…	40	…	40	…	
Solubility in trichloroethylene, %	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…	
Float test, 60°C (140°F), s	…	…	…	…	1200	…	…	…	…	…	…	…	

Type	Medium-Setting						Slow-Setting						Quick Setting	
Grade	HFMS-1		HFMS-2		HFMS-2h		HFMS-2s		SS-1		SS-1h		QS-1H	
	min	max	min	Max	Min	max	min	max	min	max	min	max	min	max
Tests on emulsions														
Viscosity, Saybolt Furol at 25°C (77°F), SFS	20	100	100	…	100	…	50	…	20	100	20	100	20	100
Viscosity, Saybolt Furol at 50°C (122°F), SFS	…	…	…	…	…	…	…	…	…	…	…	…		
Storage stability test, 24-h, %	…	1	…	1	…	1	…	1	…	1	…	1		
Demulsibility, 35 ml, 0.02 N CaCl2, %	…	…	…	…	…	…	…	…	…	…	…	…		
Coating ability and water resistance:														
Coating, dry aggregate	good		good		Good		good		…		…			
Coating, after spraying	fair		fair		Fair		fair		…		…			
Coating, wet aggregate	fair		fair		Fair		fair		…		…			
Coating, after spraying	fair		fair		Fair		fair		…		…			
Cement mixing test, %	…	…	…	…	…	…	…	…	…	2.0	…	2.0		N/H
Sieve test, %	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10
Residue by distillation, %	55	…	65	…	65	…	65	…	57	…	57	…	57	
Oil distillate by volume of emulsion,%	…	…	…	…	…	…	1	7	…	…	…	…		
Tests on residue from distillation test:														
Penetration, 25°C (77°F), 100g, 5 s	100	200	100	200	40	90	200	…	100	200	40	90	40	90
Ductility, 25°C (77°F) 5 cm/min, cm	40	…	40	…	40	…	40	…	40	…	40	…	40	…
Solubility in trichloroethylene, %	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…
Float test, 60°C (140°F), s	1200	…	1200	…	1200	…	1200	…	…	…	…	…	…	…

TABLE 312-2: Requirements for Cationic Emulsified Asphalt

NOTE 1—CQS-1H emulsions shall meet the requirements outlined in Practices D 3910.
NOTE 2—CQS-1h is used for Quick Set Slurry Seal systems.

Type	Rapid Setting				Medium-Setting				Slow-Setting				Quick Setting	
Grade	CRS-1		CRS-2		CMS-2		CMS-2h		CSS-1		CSS-1h		CQS-1H	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max
Tests on emulsions														
Viscosity, Saybolt Furol at 25℃ (77℉), SFS									20	100	20	100	20	100
Viscosity, Saybolt Furol at 50℃ (122℉), SFS	20	100	100	400	50	450	50	450						
Storage stability test, 24-h, %		1		1		1		1		1		1		
Demulsibility, 35 ml, 0.8% dioctyl sodium	40	…	40	…										
Coating ability and water resistance:														
Coating, dry aggregate					good		good							
Coating, after spraying					fair		fair							
Coating, wet aggregate					fair		fair							
Coating, after spraying					fair		fair							
Particle charge test	positive		positive		positive		positive		positive		positive		positive	
Sieve test, %		0.10		0.10		0.10		0.10		0.10		0.10		0.10
Cement mixing test, %										2.0		2.0		N/A
Oil distillate by volume of emulsion, %		3		3		12		12						
Residue:%	60		65		65		65		57		57		57	
Penetration, 25℃ (77℉), 100g, 5 s	100	252	100	250	100	250	40	90	100	250	40	90	40	90
Ductility, 25℃ (77℉) 5 cm/min, cm	40		40		40		40		40		40		40	
Solubility in trichloroethylene, %	97.5		97.5		97.5		97.5		97.5		97.5		97.5	

312.3.2 Types of Asphalt Emulsion Treatments and Seal Coats

Emulsified Asphalt shall be used in one or more of the following applications as per drawings and instructions of the Engineer.

Surface Treatment shall include several types of asphalt and asphalt-aggregate applications usually less than 25mm thick and applied on any kind of road surface. If surface treatment is to be applied on granular base/sub-base, it shall be primed prior to surface treatment.

Seal Coats shall include surface treatments applied on existing pavement surfaces, whether asphalt pavements or Portland cement concrete pavements.

The contractor shall execute all/any type of work with appropriate equipment required for the job as approved by the Engineer. The work shall include all activities i.e. transportation, laying, spreading, compaction etc. as required by the type of application and nature of work.

Guidance shall be taken from other relevant sections of this specification for any activity not covered under this item of work.

The Emulsion application temperatures for all type of applications shall be as listed in Table 313-3

Table 312-3

Suggested Distributor Spraying Temperatures for Various Grades of Asphalt Emulsion

Type and Grade of Asphalt	Spraying Temperatures (*C)	Type and Grade of Asphalt	Spraying Temperatures (*C)
Asphalt Emulsion*		**Asphalt Emulsion***	
RS-1	20-60	HFMS-2s	20-70
RS-2	50-85	SS-1	20-70
HFRS-2	50-85	SS-1h	20-70
MS-1	20-70	CRS-1	50-85
MS-2	20-70	CRS-2	50-85
MS-2h	20-70	CMS-2	20-70
HFMS-1	20-70	CMS-2h	20-70
HFMS-2	20-70	CSS-1	20-70
HFMS-2h	20-70	CSS-1h	20-70

* Temperatures also apply to polymer-modified versions of these emulsions.

312.3.2.1 Single Surface Treatment

A single surface treatment, often called a “chip seal” may be used for one of several reasons:

- As an interim measure pending application of an asphalt mixture
- To correct surface raveling and oxidation of old pavements
- To provide a waterproof, skid resistance surface over an existing pavement structure

A single treatment is suitable for light to medium duty traffic and as a preventive or interim maintenance procedure. For higher traffic roads, multiple surface treatments shall be considered. Single treatments may also be used following crack sealing. The surface treatment shall also be applied to resist the abrasive forces of the traffic.

Table 312-4: Quantities of Asphalt and Aggregate for Single Surface Treatment

Nominal Size of Aggregate	Size No.	Quantity of Aggregate (kg/m^2)	Quantity of Asphalt (lit/m^2)	Type and Grade of Asphalt*
19.0 to 9.5mm (3/4 to 3/8 in.)	6	22-27	1.8-2.3	RS-2, CRS-2
12.5 to 4.75 mm (1/2 in. to No.2)	7	14-16	1.4-2.0	RS-1, RS-2 CRS-1, CRS-2
9.5 to 2.36 mm (3/8 in. to No. 8)	8	11-14	0.9-1.6	RS-1, RS-2 CRS-1, CRS-2
4.75 to 1.18 mm (No.4 to No. 16)	9	8-11	0.7-0.9	RS-1, MS-1, CRS-1, HFRS-2
Sand	AASHTO M-6	5-8	0.5-0.7	RS-1, MS-1, CRS-1, HFRS-2

* Including polymer modified versions of these emulsions

1. These quantities of asphalt cover the average range of conditions that include primed granular bases and old pavement surfaces. The quantities and types of materials may be varied according to local conditions and experience
2. The lower application rates of asphalt shown in the above table should be used for aggregate having gradations on the fine side of the specification limits. The higher application rates should be used for aggregate having gradations on the coarse side of the specified limits.
3. It is important to adjust the asphalt quantity for the surface condition of the road, increasing it if the road is absorbent, badly cracked, or coarse and decreasing it if the road is flushed with asphalt. (See table below.)

Correction for Surface Condition

Pavement Texture	Correction (lit/m^2)**
Black, flushed asphalt	-0.04 to -0.27
Smooth, non-porous	0.00
Absorbent – slightly porous, oxidized	+0.14
- slightly pocked, porous, oxidized	+0.27
- badly pocked, porous, oxidized	+0.40

** This correction must be made from observations at the job site.

312.3.2.2 Multiple Surface Treatments

A multiple treatment shall produce a surface thickness between 12mm to 20mm as shown on drawings. In a double or triple surface treatment, the largest size of stone in the first course shall determine the surface layer thickness. The subsequent courses shall serve to fill the voids in the mat of the first cover aggregate.

Table 312-5: Quantities of Asphalt and Aggregate for Double Surface Treatment

Total Thickness	Nominal Size of Aggregate	Size No.	Quantity of Aggregate (kg/m^2)	Quantity of Asphalt (lit/m^2)
12.5mm Thick				
1st Application*	9.5 to 2.36mm (3/8 in. to No. 8)	8	14-19	0.9-1.4
2nd Application	4.75 to 1.18 mm (No.4 to No. 16)	9	5-8	1.4-1.8
15.9mm Thick				
1st Application*	12.5 to 4.75mm (1/2 in. to No. 4)	7	16-22	1.4-1.8
2nd Application	4.75 to 1.18 mm (No.4 to No. 16)	9	8-11	1.8-2.3
19.0mm Thick				
1st Application*	19.0 to 9.5mm (3/4 in. to 3/8 in.)	6	22-27	1.6-2.3
2nd Application	9.5 to 2.36 mm (3/4 in. to No.8)	8	11-14	2.3-2.7

* If applied on untreated granular base, a penetrating prime coat is used in lieu of emulsion

1. These quantities of asphalt cover the average range of conditions that include primed granular bases and old pavement surfaces. The quantities and types of materials may be varied according to local conditions and experience
2. The lower application rates of asphalt shown in the above table should be used for aggregate having gradations on the fine side of the specification limits. The higher application rates should be used for aggregate having gradations on the coarse side of the specified limits.
3. It is important to adjust the asphalt quantity for the surface condition of the road, increasing it if the road is absorbent, badly cracked, or coarse and decreasing it if the road is flushed with asphalt. (See table below.)

Correction for Surface Condition	
Pavement Texture	**Correction (lit/m^2)****
Black, flushed asphalt	-0.04 to -0.27
Smooth, non-porous	0.00
Absorbent – slightly porous, oxidized	+0.14
- slightly pocked, porous, oxidized	+0.27
- badly pocked, porous, oxidized	+0.40

** This correction must be made from observations at the job site for the first application.

Table 312-6: Quantities of Asphalt and Aggregate for Triple Surface Treatment

Total Thickness	Nominal Size of Aggregate	Size No.	Quantity of Aggregate (kg/m^2)	Quantity of Asphalt (lit/m^2)
12.5mm Thick				
1st Application*	9.5 to 2.36mm (3/8 in. to No. 8)	8	14-19	0.9-1.4
2nd Application	4.75 to 1.18 mm (No.4 to No. 16)	9	5-8	1.4-1.6
3rd Application	4.75mm to 150µm (No. 4 to No. 100)	10	5-8	0.9-1.4
15.9mm Thick				
1st Application*	12.5 to 4.75mm (1/2 in. to No. 4)	7	16-22	0.9-1.4
2nd Application	9.5 to 2.36mm (3/8 in. to No. 8)	8	8-11	1.4-1.8
3rd Application	4.75 to 1.18 mm (No.4 to No. 16)	9	5-8	0.9-1.4
19.0mm Thick				
1st Application*	19.0 to 9.5mm (3/4 in. to 3/8 in.)	6	19-25	1.1-1.6
2nd Application	9.5 to 2.36 mm (3/4 in. to No.8)	8	11-14	1.4-1.8
3rd Application	4.75 to 1.18 mm (No. 4 to No.16)	9	5-8	1.1-1.6
* If applied on untreated granular base, a penetrating prime coat is used in lieu of emulsion				

1. These quantities of asphalt cover the average range of conditions that include primed granular bases and old pavement surfaces. The quantities and types of materials may be varied according to local conditions and experience
2. The lower application rates of asphalt shown in the above table should be used for aggregate having gradations on the fine side of the specification limits. The higher application rates should be used for aggregate having gradations on the coarse side of the specified limits.
3. It is important to adjust the asphalt quantity for the surface condition of the road, increasing it if the road is absorbent, badly cracked, or coarse and decreasing it if the road is flushed with asphalt. (See table below.)

Correction for Surface Condition	
Pavement Texture	**Correction (lit/m^2)****
Black, flushed asphalt	-0.04 to -0.27
Smooth, non-porous	0.00
Absorbent – slightly porous, oxidized	+0.14
- slightly pocked, porous, oxidized	+0.27
- badly pocked, porous, oxidized	+0.40
** This correction must be made from observations at the job site for the first application.	

Other Construction Requirements for all three types of surfaces treatments shall comply with relevant articles of Item 304 “Bituminous Surface treatment and Seal/Pad Coat”

312.3.2.3 Sand Seal

A sand seal is a spray application of asphalt emulsion followed with a light covering of fine aggregate, such as clean sand or screenings.

RS-1, CRS-1, MS-1 or HFMS-1 emulsions shall be applied within a range of 0.70 to 1.25 Lit/sq. meter depending on the existing surface condition. This shall be followed by 5.5 to 12 kg/sq. meter of sand or screenings cover rolled into place. The quantity of emulsion and sand shall be so adjusted to give a final finish which shall neither have excess asphalt nor uncoated sand.

The sand seal shall be used primarily to:

- Enrich a dry, weathered or oxidized surface. The sand seal will help prevent loss of material from the old surface by traffic abrasion.

- Prevent the intrusion of moisture and air. When an existing pavement surface begins to crack, moisture and air may pass into the under laying pavement structure thereby reducing its load carrying ability. A sand seal can provide a barrier to prevent this intrusion.

- Develop a skid –resistant surface texture. By selecting a sharp, angular fine aggregate, a highly skid-resistant surface can be provided. Examples of angular aggregates are slag sand, or other manufactured sands. The sand may also be used to “soak up” spots of asphalt that have appeared because of an overly rich surface.

312.3.2.4 Slurry Seal

A slurry seal shall be a mixture of dense graded aggregate, emulsified asphalt, fillers, additives and water. The mixture shall be applied as a surface treatment for both a preventive and a corrective maintenance measures. Any pavement that is structurally weak in localized areas shall be repaired before applying the slurry seal. Ruts, humps, low pavement edges, crown deficiencies, or to the surface irregularities that diminish riding quality shall be corrected before placing the slurry seal.

Slurry seal when used as a maintenance measure for the surfaces of older pavements shall fill the surface cracks, stop raveling and loss of matrix, improve skid resistance and generally protect the pavement and reduce water and oxidation deterioration and thus extend overall pavement service life.

Slurry seal shall be applied in a thickness of 3 to 9 mm (1/8 to 3/8 in.) as specified. Machine used for mixing and application shall be a self-contained, continuous-flow mixing unit. It shall accurately delivers to the mixing chamber predetermined amounts of aggregate, mineral fillers, additives, water and asphalt emulsion.

Type I. This aggregate gradation is used to fill surface voids, address moderate surface distresses, and provide protection from the elements. The fineness of this mixture provides the ability for some crack penetration.

Type II. This aggregate gradation is used to fill surface voids, address more severe surface distresses, seal, and provide a durable wearing surface.

Type III. This aggregate gradation provides maximum skid resistance and an improved wearing surface.

Table 312-7: Slurry Seal Aggregate Gradings

Gradation Type	I	II	III
General Usage	**Crack filling & fine seal**	**General seal, medium textured surface**	**Produces highly textured surfaces**
Sieve Size	**Percent Passing**	**Percent Passing**	**Percent Passing**
9.5 mm (3/8 in.)	100	100	100
4.75 mm (No. 4)	100	90-100	70-90
2.36 mm (No. 8)	90-100	65-90	45-70
1.18 mm (No. 16)	65-90	45-70	28-50
600 µm (No. 30)	40-65	30-50	19-34
300 µm(No. 50)	25-42	18-30	12-25
150 µm (No. 100)	15-30	10-21	7-18
75 µm (No. 200)	10-20	5-15	5-15
Residual Asphalt Content, % weight of dry aggregate	10-16	7.5-13.5	6.5-12
Application Rate, kg/m^2, based on weight of dry aggregate	3.6-5.4	5.4-9.1	8.2-13.6

Slurry seal aggregate shall be clean, angular, durable, well graded, and uniform. A 100% crushed material should be used. An individual aggregate or a blend of aggregates to be used in a slurry mix shall meet following limits.

Test	Standard	Specification
Sand equivalent value	AASHTO T-176	45 minimum.
Soundness	AASHTO T104	10% maximum using Na_2SO_4
Los Angeles abrasion loss	AASHTO T 96 Grading C or D	30% maximum.

All areas of failure in the pavement shall be repaired before application of slurry seal and surface shall be cleaned of all loose and foreign material.

Tack coat shall be applied on the surface if surface is extremely dry and raveled or is concrete or brick. Tack coat shall consist of one part Emulsified Asphalt to three part Water.

Application of slurry seal shall be done in such a way that there shall be no lumping, balling, or unmixed aggregates visible in the spreader box. If required, slurry seal shall be compacted by pneumatic tire roller (PTR)

after it has set enough to take the load of the roller without sticking to the tires.

Slurry seal shall not be placed when air and pavement temperature is below 10 deg. C and falling but can be applied when temperature is 7 deg. C and rising. Slurry seal shall not be applied in rain and excessive fog or when there is a possibility that it will freeze within 24 hours of application.

The slurry machine shall have a continuous flow mixing unit with either a single or double shafted pugmill. Mixed slurry seal shall be discharged form the pugmill in to a spreader box. The spreader box shall equipped with flexible squeegees and shall have an adjustable width. Spreader boxes may be equipped with hydraulically powered augers to uniformly distribute material across the spreader box width. Augured boxes shall be employed when quick-set (QS) emulsions are used or when the pavement contains grades greater than 8%.

Mix Design for Slurry Seal

Asphalt emulsion used in slurry seal shall be one of the following: SS-1, CSS-1, SS-1h, CSS-1h or CQS-1h. The correct emulsion shall be selected based on the mix design. The mix design shall be completed using materials consistent with those supplied by the contractor for the project. Mix design shall be carried out as per Technical Bulletins of International Slurry Surfacing Association (www.slurry.org). Mix design properties shall conform to ISSA A105 guidelines (2010 or later edition) and shall meet the following requirements listed in Table 313-8.

Mix design may be carried out as per any other internationally recognized method if approved by the Engineer.

Table 312-8: Mix Design Recommended Tests and Values for Slurry Seal

TEST	ISSA TB NO.	SPECIFICATION
Mix Time @ 77°F (25°C)	TB 113	Controllable to 180 Seconds (Minimum)
Slurry Seal Consistency	TB 106	2.0 – 3.0 cm
Wet Cohesion @ 30 Minutes Minimum (Set) @ 60 Minutes Minimum (Traffic)	TB 139 (For quick-traffic systems)	 12 kg-cm (Minimum) 20 kg-cm or Near Spin (Minimum)
Wet Stripping	TB 114	Pass (90% Minimum)
Wet-Track Abrasion Loss One-hour Soak	TB 100	807 g / sq. m (Maximum)
Excess Asphalt by LWT Sand Adhesion	TB 109 (Critical in heavy-traffic areas)	538 g / sq. m (Maximum)

The component materials shall be designed within the following limits:

COMPONENT MATERIALS	SPECIFIED LIMITS
Residual Asphalt	Type-I 10.0 – 16.0 % Type-II 7.5 – 13.5 % Type-III 6.5 – 12.0 % Based on dry weight of aggregate

Mineral Filler	0.0 - 3.0% by dry weight of aggregate
Additives	As needed
Water	As required to produce proper mix consistency

Site tolerances for the slurry seal mixture are as follows:

a. After the residual asphalt content is determined, a variation ±1.0% by weight of dry aggregate will be permitted.

b. The slurry consistency, as determined according to ISSA TB No. 106, shall not vary more than ± 0.5 cm from the job mix formula after field adjustments.

c. The rate of application shall not vary more than ± 1.1 kg / sq. m when the surface texture does not vary significantly.

312.3.2.5 Micro-Surfacing

Micro surfacing shall consist of a mixture of polymer-modified emulsified asphalt, well graded mineral aggregate, water, and additives, proportioned, mixed and uniformly spread over a properly prepared surface as directed by the Engineer. Micro surfacing shall be capable of performing in variable thickness cross-sections such as ruts, scratch courses and milled surfaces. After curing and initial traffic consolidation, it shall resist further compaction. The micro surfacing shall be applied as a homogeneous mat, adhere firmly to the prepared surface, and have a skid resistant texture throughout its service life.

Micro surfacing shall be placed by specialized, compartmented, self powered, continuous lay down micro-surfacing trucks with highly accurate proportioning system.

As a surface treatment, micro-surfacing shall impart protection to the under-laying pavement and provide renewed surface friction values. Special emulsifiers in micro-surfacing emulsions contribute quick setting characteristics. Formulations shall be required under average conditions to allow the return of straight running traffic to the surface in one hour. Minor re-profiling shall be achieved with multiple applications.

Micro-surfacing features and application shall include:

- Quick set, quick traffic feature.
- Chemical break permitting night time application.
- Suitability for use on high traffic volume, limited access highways.
- Single pass application rates of 11 to 16 kg/m^2, yielding micro-surfacing depths from 9 to 16 mm in depth.
- Scratch course followed by a finishing course providing minor re-profiling and a new riding surface.
- Rut filling followed by a finishing course providing proper water drainage and reducing the possibility of vehicle hydroplaning.

The mineral aggregate used shall be the type specified for the particular application requirements of the micro surfacing. The aggregate shall be a crushed stone such as granite, slag, limestone or other high-quality aggregate, or combination thereof. To assure the material is 100 percent crushed, the parent aggregate will be larger than the largest stone in the gradation used.

Following types of micro-surfacing treatments may be applied as shown on drawings.

Type II. This aggregate gradation is used to fill surface voids, address surface distresses, seal, and provide a durable wearing surface.

Type III. This aggregate gradation provides maximum skid resistance and an improved wearing surface. This type of micro surfacing surface is appropriate for heavily traveled pavements, rut filling, or for placement on highly textured surfaces requiring larger size aggregate to fill voids.

Aggregate grading for micro-surfacing shall conform to Table 313-9.

Table 312-9: Micro-Surfacing Aggregate Gradings

Gradation Type	**II**	**III**
Sieve Size	**Percent Passing**	**Percent Passing**
9.5mm (3/8 in.)	100	100
4.75 mm (No. 4)	90 – 100	70 – 90
2.36 mm (No. 8)	65 – 90	45 – 70
1.18 mm (No. 16)	45 – 70	28 – 50
600 µm (No. 30)	30 – 50	19 – 34
300 µm (No. 50)	18 – 30	12 – 25
150 µm (No. 100)	10 – 21	7 – 18
75 µm (No. 200)	5 – 15	5 – 15
Residual Asphalt Content, % weight of dry aggregate	5.5 – 9.5	5.5 – 9.5
Application Rate, kg/sq. m based on weight of dry aggregate	5.4 – 9.1	8.2 – 13.6

An individual aggregate or a blend of aggregates to be used in a slurry mix shall meet following limits.

Test	**Standard**	**Specification**
Sand equivalent value	AASHTO T-176	65 minimum.
Soundness	AASHTO T104	10% maximum using Na_2SO_4
Los Angeles abrasion loss	AASHTO T 96 Grading C or D	30% maximum.

Micro-surfacing shall not be placed when air and pavement temperature is below 10 deg. C and falling but can be applied when temperature is 7 deg. C and rising. Slurry seal shall not be applied in rain and excessive fog or when there is a possibility that it will freeze within 24 hours of application.

Mix Design for Micro Surfacing

A micro-surfacing mix design shall be performed in the laboratory prior to application. The mix design shall be completed using materials consistent with those supplied by the contractor for the project. Mix design shall be carried out as per Technical Bulletins of International Slurry Surfacing Association (www.slurry.org). Mix design properties shall conform to ISSA A143 guidelines (2010 or later edition) and shall meet the following requirements listed in Table 313-10.

Mix design may be carried out as per any other internationally recognized method if approved by the Engineer.

Table 312-10: Mix Design Recommended Tests and Values for Micro Surfacing

TEST	ISSA TB NO.	SPECIFICATION
Mix Time @ 77°F (25°C)	TB 113	Controllable to 120 Seconds (Minimum)
Wet Cohesion @ 30 Minutes Minimum (Set) @ 60 Minutes Minimum (Traffic)	TB 139	 12 kg-cm (Minimum) 20 kg-cm or Near Spin (Minimum)
Wet Stripping	TB 114	Pass (90% Minimum)
Wet-Track Abrasion Loss One-hour Soak Six-day Soak	TB 100	 538 g / sq. m (Maximum) 807 g / sq. m (Maximum)
Lateral Displacement	TB 147	5% (Maximum)
Specific Gravity after 1000 cycles of 56.71 kg (125 lb)	TB 147	2.10 (Maximum)
Excess Asphalt by LWT Sand Adhesion	TB 109	538 g / sq. m (Maximum)
Classification Compatibility	TB 144	11 Grade Points (Minimum) (AAA, BAA)

The component materials shall be designed within the following limits:

COMPONENT MATERIALS	SPECIFIED LIMITS
Residual Asphalt	5.5 - 10.5% by dry weight of aggregate
Mineral Filler	0.0 - 3.0% by dry weight of aggregate
Polymer Content	Minimum of 3.0% solids based on bitumen weight content
Additives	As needed
Water	As required to produce proper mix consistency

312.3.3 Emulsified Asphalt Aggregate Mixes

Asphalt emulsion aggregate mixtures shall be any of the following three types as specified; dense-graded, sand and open-graded. Dense-graded mixtures have aggregates that are graded from the maximum size down to and including material passing the 75µm (No.200) sieve. They include a wide variety of aggregate types and gradations and can be used for all types of pavement applications.

Sand emulsion mixtures are produced by treating bank-run sands, poorly graded sand-gravels and “dune” or “sugar” sands with asphalt emulsions. Sand mixes are generally restricted to fine granular sands and silty sands low in clay content. Sand mixes have provided good performance as sub-base and base layers when produced with the proper emulsion grades. For these mixes, the emulsions typically used are slow setting and high float medium setting, with harder or “h” grades preferred.

Open-graded mixtures provide high air voids to drain water through the mix. These mixtures have been used very successfully for both base

and surface courses. Because of the relatively simple plant equipment required and high mix production rates possible, these mixes are economically attractive when a high quality mix is required for heavy traffic loading. These mixes have good resistance to fatigue, reflection cracking, rutting and shoving.

The following types and gradations of aggregates listed in Tables 313-11, 313-12 and 313-13 shall be used for emulsion mixes.

Table 312-11: Aggregate for Dense-Graded Emulsion Mixtures

Sieve Size	Semi-Processed Crusher, Pit or Bank Run	Processed Dense-Graded Asphalt Mixtures Percent passing by Weight				
50mm (2 in.)	-	100	-	-	-	-
37.5mm (1-12 in.)	100	90-100	100	-	-	-
25.0mm (1 in.)	80-90	-	90-100	100	-	-
19.0mm (3/4 in.)	-	60-80	-	90-100	100	-
12.5mm (1/2 in.)	-	-	60-80	-	90-100	100
9.5mm (3/8 in.)	-	-	-	60-80	-	90-100
4.75 mm (No. 4)	25-85	20-55	25-60	35-65	45-70	60-80
2.36 mm (No. 8)	-	10-40	15-45	20-50	25-55	35-65
1.18 mm (No. 16)	-	-	-	-	-	-
600 µm (No. 30)	-	-	-	-	-	-
300 µm(No. 50)	-	2-16	3-18	3-20	5-20	6-25
150 µm (No. 100)	-	-	-	-	-	-
75 µm (No. 200)	3-15	0.5	1-7	2.8	2-9	2-10
Sand Equivalent, Percent	30 min.	35 min.	35 min.	35 min.	35 min.	35 min.
Los Angeles Abrasion @500 Revolutions	-	40 max	40 max	40 max	40 max	40 max
Percent Crushed Faces	-	65 min	65 min	65 min	65 min	65 min

Table 312-12: Aggregate for Open-Graded Emulsion Mixtures

Sieve Size	Aggregate Base			Open-Graded Surface Course
	Coarse	Medium	Fine	
37.5mm (1-12 in.)	100	-	-	-
25.0mm (1 in.)	95-100	100	-	-
19.0mm (3/4 in.)	-	90-100	-	-
12.5mm (1/2 in.)	25-60	-	100	-
9.5mm (3/8 in.)	-	20-55	85-100	100
4.75 mm (No. 4)	0-10	0-10	-	30-50
2.36 mm (No. 8)	0-5	0-5	0-10	5-15
1.18 mm (No. 16)	-	-	0-5	-
75µm (No. 200)	0-2	0-2	0-2	0-2
Los Angeles Abrasion @ 500 Revolutions	40 Max.	40 Max.	40 Max.	40 Max.
Percent Crushed Faces	65 Min.	65 Min.	65 Min.	65 Min.

Table 312-13: Aggregates for Sand Emulsion Mixtures

Sieve Size	Total Percent Passing		
	Poorly-Graded	Well-Graded	Silty Sands
12.5mm (1/2 in.)	100	100	100
4.75 mm (No. 4)	75-100	75-100	75-100
300 µm (No. 50)	-	15-30	-
150 µm (No. 100)	-	-	15-65
75µm (No. 200)	0-12	5-12	12-20
Plasticity Index	Zero	Zero	Zero

The aggregates shall be compatible with the type of emulsion used for the specific job. Mix design shall be prepared in laboratory and approved by the Engineer, prior to execution of work at site. The mineral aggregates shall be tested by methods listed in Table 313-14

Any additives i.e. Portland cement or hydrated lime, if used in the mix design shall be between one (1) and two (2) percent by weight of dry aggregate.

Table 312-14: Aggregate Evaluation Procedures

Characteristics	Method of Test	
	ASTM	AASHTO
Amount of Material finer than 75 µm (No. 200) Sieve in aggregate	C 117	T 11
Unit weight of aggregate	C 29	T 19
Sieve analysis, fine and coarse aggregates	C 136	T 27
Sieve analysis of mineral filler	D 546	T 37
Abrasion of coarse aggregates Los Angeles Machine	C 131	T 96
Plastic fines in graded aggregates and soils by use of the Sand Equivalent Test	D 2419	T 176

Mix Design

Mix Design for Emulsion Aggregate Mixes shall be prepared as per Asphalt Institute Manual Series No. 19 (third edition or later).

Mixing, Spreading and Compaction

Following methods may be employed by the contractor to produce emulsion aggregate mixes at site.

a. Rotary Mixer machine.
b. Road Reclaiming machine.
c. Central travelling mixing plant.

Motor grader shall only be allowed to be used for mixing for short lengths or small areas, upon approval by the Engineer.

The mixture shall be spread to a uniform thickness so that no thin areas exist in the final mat. No layer shall be thinner than two times the maximum dimension of the largest aggregate or thicker than 150mm. Sand mixes shall not be placed in compacted thicknesses of more than 50mm per layer.

Initial rolling of emulsion mixes shall begin as the emulsion begins to break. Breaking is indicated by noticeable change in color from brown to black. Rolling shall be done with a pneumatic-tired roller. If the mixture ruts or shoves during initial compaction, further time shall be given before rolling. After one layer has been thoroughly compacted, next layer shall be placed on it. When mat has been shaped to its final required cross-section, finish rolling with a steel-wheeled roller shall be done until all roller and other marks are eliminated.

312.4 MEASUREMENT AND PAYMENT

312.4.1 Measurement

The quantity of Emulsified Asphalt applications to be paid for shall be measured in square meter or cubic meter within the theoretical line in place as shown on drawing. No allowance will be given for material placed outside the theoretical limits of finished surfacing whether placed due to requirement of contractor's operations or placed out side the limits due to inadequate control.

312.4.2 Payment

The aggregate and asphaltic material measured as stated above shall be paid for at the contract unit price per square meter or cubic meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, materials, tools, equipment and incidental for performing all the work in the construction of any type of Emulsified Asphalt applications complete in place and according to specification, including priming of surface for single, double and triple surface treatments only. If priming is required for other items of work, it shall be paid under relevant BOQ item.

Pay Item No.	Description	Unit of Measurement
312 a	Single Surface Treatment (with Emulsified Asphalt)	SM
312 b	Double surface Treatment (with Emulsified Asphalt)	SM
312 c	Triple Surface Treatment (with Emulsified Asphalt)	SM
312 d	Sand Seal	SM
312 e	Slurry Seal – Type ___	SM
312 f	Micro Surfacing – Type ___	SM
312 g	Emulsion Aggregate Mix Type ____	CM

SECTION 313 SUPERIOR PERFORMANCE ASPHALT PAVEMENT (SUPERPAVE)

313.1 DESCRIPTION

This section includes provision of the asphalt binder which satisfies the required performance specifications for the project area and selection of the suitable aggregate in terms of gradation and quality requirements for production of an asphalt mix which satisfies the performance requirements and design conditions stated in this General Specification, and hauling, spreading and compacting the mix for construction of the Superior Performance Asphalt Pavement (SUPERPAVE) layers in accordance with the plans, contract documents and this General Specification.

Superpave material specifications and mix design procedures shall comply with latest version of the following documents:

- AASHTO M-320 Performance-Graded Asphalt Binder
- AASHTO M-323 Standard Specification for Superpave Volumetric Mix Design
- AASHTO R-30 Mixture Conditioning of Hot-Mix Asphalt (HMA)
- AASHTO R-35 Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
- NCHRP Report 673 A Manual for Design of Hot Mix Asphalt.

313.2 MATERIAL REQUIREMENTS

313.2.1 Asphalt

The asphalt materials used in the Superpave consist of modified or unmodified asphalt binder which shall satisfy the quality requirements shown in Table 314-2 of this general Specification. Unless otherwise defined in the contract documents, the contractor shall submit a study, prepared by a specialized authority, which shows the suitable performance grade of the asphalt binder for the project area.

The performance grade shall be determined according to the sequence followed in the standard AASHTO PP-6 “The Standard Method of Approving the Suppliers Grade of the Asphalt Binder” and AASHTO M-320 “Performance-Graded Asphalt Binder”.

The performance grade of the asphalt binder shall be selected on the basis of temperatures of the project location in any zone, using the equations 1 and 2. In case there is no such data available for the project site, the performance grades shown in Figure 314-A “Performance Grade Zones of the Pakistan” or the nearest location from Table 314-1 shall be used as approved by the Engineer.

Figure 313-A: Performance Grade Zones of Pakistan

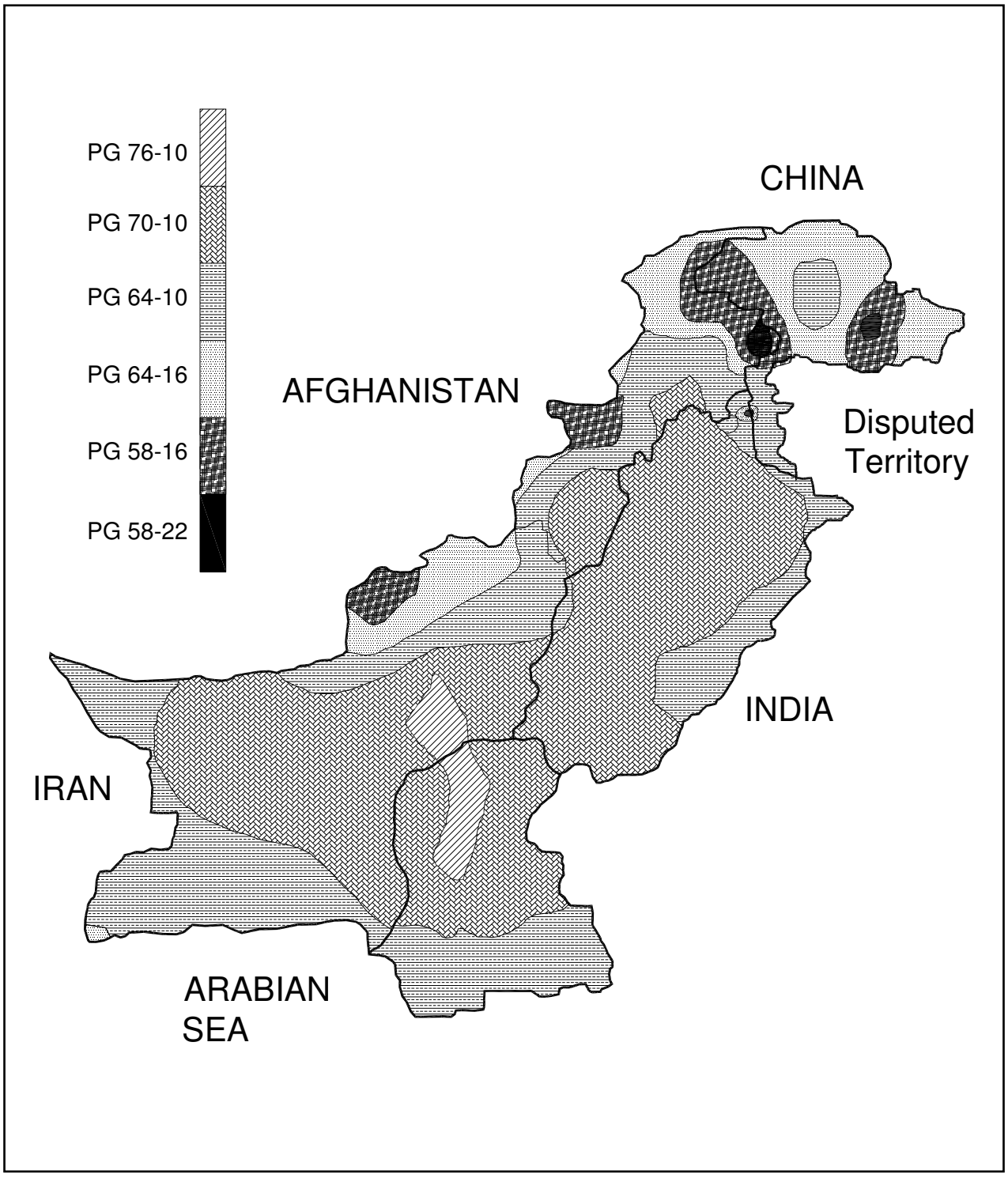


Table 313-1: Performance Grading for Various Cities of Pakistan

No.	Location	PG Grade @ 98% Reliability	No.	Location	PG Grade @ 98% Reliability
1.	Bagh	PG 64-10	33.	Massan	PG 70-10
2.	Bahawalpur	PG 70-10	34.	Miani Forest	PG 76-10
3.	Bannu	PG 70-10	35.	Multan	PG 70-10
4.	Besham Qila	PG 70-10	36.	Munda Dam	PG 70-10
5.	Chillya	PG 70-10	37.	Murree	PG 58-10
6.	Chitral	PG 64-10	38.	Nabi Sar	PG 70-10
7.	Daggar	PG 70-10	39.	Naran	PG 58-16
8.	Dainyar	PG 70-10	40.	Nokkundi	PG 70-10
9.	Dalbandin	PG 70-10	41.	Oghi	PG 64-10
10.	Domel	PG 70-10	42.	Panjgur	PG 70-10
11.	Doyian	PG 64-10	43.	Parahinar	PG 64-16
12.	Faisalabad	PG 70-10	44.	Pasni	PG 64-10
13.	Fort Lock	PG 58-10	45.	Peshawar	PG 70-10
14.	Gilgit	PG 70-10	46.	Phulra	PG 70-10
15.	Gujar Khan	PG 70-10	47.	Plandri	PG 64-10
16.	Gungi	PG 64-10	48.	Quetta	PG 70-10
17.	Hub Dam	PG 70-10	49.	Rehmab Br.	PG 70-10
18.	Hyderabad	PG 70-10	50.	Rohri	PG 70-10
19.	Islamabad	PG 70-10	51.	Sakrand	PG 76-10
20.	Jacobabad	PG 76-10	52.	Sargodha	PG 70-10
21.	Kachur	PG 64-10	53.	Sehwan	PG 76-10
22.	Kakul	PG 64-10	54.	Shinkiari	PG 64-10
23.	Kalabagh	PG 70-10	55.	Sialkot	PG 70-10
24.	Kalam	PG 58-16	56.	Sibbi	PG 76-10
25.	Kallar	PG 64-10	57.	Skardu	PG 64-16
26.	Kandia	PG 70-10	58.	Sukkar	PG 70-10
27.	Karachi	PG 64-10	59.	Tank	PG 76-10
28.	Karimabad	PG 64-10	60.	Tarbela	PG 70-10
29.	Khuzdar	PG 70-10	61.	Thana Bulla	PG 70-10
30.	Lahore	PG 70-10	62.	Yugo	PG 64-10
31.	Mangla	PG 70-10	63.	Zhob	PG 70-10
32.	Mardan	PG 70-10	64.	Zulam Br.	PG 70-10

Maximum Pavement Design Temperature

Determination of the maximum pavement temperature as the temperature at a depth of twenty (20) millimeters below the top of respective pavement layers, by using the average air temperature for the hottest seven days during the monitoring period and the geographical location of the project (latitude), and using the following equation:

$$\textbf{High, } T_{pav} = 54.32 + 0.78T_{air} - 0.0025Lat^2 - 15.14\ Log_{10}(H + 25) + Z(9 + 0.61\sigma_{air}^2)^{0.5} \quad (1)$$

Where:

T_{pav} = Maximum pavement design temperature at H mm depth from pavement surface, deg. C.

T_{air} = Average hottest seven days air temperature, deg. C.

Lat = Geographical location of the project (latitude) in degrees.

Z = Reliability factor = 2.055 at 98% reliability.

H = Depth from surface to 20mm below the top of asphaltic layer. (= 20mm for Wearing Course)

σ_{air} = Standard deviation of maximum seven day air temperature.

Minimum Pavement Design Temperature

Determination of the minimum pavement temperature at the surface / top of respective pavement layers using the minimum air temperature in the monitored period or by applying the following equation:

$$\textbf{Low, } T_{pav} = -1.56 + 0.72T_{air} - 0.004Lat^2 + 6.26\ Log_{10}(H+25) - Z(4.4 + 0.52\sigma_{air}^2)^{0.5} \quad (2)$$

Where;

T_{pav} = Minimum pavement design temperature, deg C at H mm depth from the surface.

T_{air} = Minimum daily air temperature, deg. C

Lat = Geographical location of the project (latitude) in degrees.

Z = Reliability factor = 2.055 at 98% reliability.

H = Depth from surface to the top of asphaltic layer (= 0mm for Wearing Course)

σ_{air} = Standard deviation of minimum air daily temperature.

This selected grade shall be increased by the number of performance categories shown in Table 314-3, according to the speed and the design traffic volume in ESAL's in the design lane for twenty (20) years. The properties of the selected asphalt binder shall conform to the requirements shown in Table 314-2.

When the available asphalt binder does not satisfy the performance requirements, the Contractor shall modify the asphalt binder by using one of the approved and common modifiers. He shall also submit technical report, prepared by specialized authority, showing the proposed polymer type, its percentage, method of addition and test results which verify the satisfaction of the asphalt binder type to the quality requirements shown in Table 314-4 (a), (b) & (c).

Table 313-2: Quality Requirements of Performance Grades of Asphalt Binder

Test		Description	Specification	Requirements
New Asphalt				
Flash Point		Cleveland Open Cup	AASHTO T-48	230 ℃ (min)
Rotational Viscosity		At 135 ℃	AASHTO T-316	3.0 Pa-sec (max)
Dynamic Shear (DSR) G*/sinδ at 10 rad/sec		At the higher Temperature	AASHTO T-315	1.00 kPa (min)
Specimens of Asphalt Residue from RTFO				
Mass loss (RTFO), %		At 163 ℃	AASHTO T-240	1.0 % (max)
Dynamic Shear (DSR), G*/sinδ at 10 rad/sec		At the higher Temperature	AASHTO T-315	2.20 kPa (min)
Specimens of Asphalt Residue from RTFO and PAV (AASHTO R-28)				
Dynamic Shear (DSR), G*/sinδ at 10 rad/sec		At Test Temperature[1]	AASHTO T-315	5000 kPa (max)
Bending Beam Rheometer	Creep Stiffness (S)	At minimum temperature +10 °C for 60 sec	AASHTO T-313	300 MPa (max)
	m-value	At minimum temperature +10 °C for 60 sec	AASHTO T-313	0.3 (min)
Direct Tension, 1.0 mm/min		At minimum Temperature	AASHTO T-314	1.0 % (min)

1 See Table 314-4 for Test Temperatures

Table 313-3: Asphalt Binder Grade Adjustment on the Basis of Traffic Volume and Speed

Traffic Speed Category	**Very Slow**	**Slow**	**Fast**
	<25 kph	**25 to <70 kph**	**≥70 kph**
Design Traffic Volume (million ESALs)	**Grade Adjustment for Traffic Speed Level Given Above and Design Traffic Level at Left:**		
< 0.3	No need		
0.3 to <3	2	1	No need
3 to <10	3[a]	2	1
10 to <30	4[a]	3[a]	2
≥30	4[a]	4[a]	3[a]

a Consider use of polymer-modified binder. If a polymer-modified binder is used, high temperature grade may be reduced one degree (6℃) provided rut resistance is verified using suitable performance testing as per NCHRP Report 673.

The selected performance grade shall be modified on the basis of climate temperature in the project area in accordance with Section 314.1, by increasing the maximum temperature only by the amount of the performance categories shown in Table 314-3,

according to the speed and design volume of traffic on the road. The minimum temperature in the performance grade shall not be modified. For example, if the selected performance grade for a project, according to the pavement temperature, is PG 70-10 and the design traffic speed is greater than seventy (70) kph and the design traffic volume is between ten (10) to thirty (30) million ESAL in the design lane, the performance grade of the asphalt binder shall be increased two categories to be of the type PG 82-10 (See Tables 314-4 (a) to (c)).

The Contractor shall use modified asphalt binder in construction of Superpave asphalt concrete according to the approval of the Engineer in any of the zones and taking into consideration that the performance category of that asphalt binder is increased according to traffic volume and speed in the target project as shown in Table 314-3.

Specification for performance-graded asphalt binders (PG 46 – PG 82) are compiled in Tables 314-4 (a), 314-4 (b) and 314-4 (c).

Table 313-4 (a): Specification for Performance-Graded Asphalt Binders (PG 46 – PG 58)

Binder Performance Grade:	PG 46			PG 52							PG 58				
	-34	-40	-46	-10	-16	-22	-28	-34	-40	-46	-16	-22	-28	-34	-40
Design high pavement Temperature, ℃:	<46			<52							<58				
Design low pavement Temperature, ℃:	≥34	≥40	≥46	≥10	≥16	≥22	≥28	≥34	≥40	≥46	≥16	≥22	≥28	≥34	≥140
Test on Original Binder															
Flash Point Temperature (T 48), Min., ℃	230														
Viscosity (T 316) Maximum value of 3 Pa-s at Test temperature, ℃	135														
Dynamic Shear (T 315) G*/sinδ minimum value 1.00 kPa, at 10 rad/s and Test Temperature, ℃	46			52							58				
Test on Residue from Rolling Thin Film Oven (T 240)															
Mass Loss, Maximum, %	1.00														
Dynamic Shear (T 315) G*/sinδ minimum value 2.20 kPa, at 10 rad/s and Test Temperature, ℃	46			52							58				
Test on Residue from Pressure Aging Vessel (R 28)															
PAV Aging Temperature, ℃	90			90							100				
Dynamic Shear (T 315) G*/sinδ minimum value 5000 kPa, at 10 rad/s and Test Temperature, ℃	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13
Creep Stiffness (T 313) Stiffiness, maximum value 300 Mpa m-value, minimum value 0.30, at 60 sec and Test Temperature, ℃	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30
Direct Tension (T 314) Failure strain, minimum value 1.0%, at 1.0 mm/min and Test Temperature, ℃	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30

Table 313-4 (b): Specification for Performance-Graded Asphalt Binders (PG 64 – PG 70)

Binder Performance Grade	PG 64						PG 70					
	-10	**-16**	**-22**	**-28**	**-34**	**-40**	**-10**	**-16**	**-22**	**-28**	**-34**	**-40**
Design high pavement Temperature, ℃:	<64						<70					
Design low pavement Temperature, ℃:	≥10	≥16	≥22	≥28	≥34	≥40	≥10	≥16	≥22	≥28	≥34	≥140
Test on Original Binder												
Flash Point Temperature (T 48), Min., ℃	230											
Viscosity (T 316) Maximum value of 3 Pa-s at Test temperature, ℃	135											
Dynamic Shear (T 315) G*/sinδ minimum value 1.00 kPa, at 10 rad/s and Test Temperature, ℃	64						70					
Test on Residue from Rolling Thin Film Oven (T 240)												
Mass Loss, Maximum %	1.00											
Dynamic Shear (T 315) G*/sinδ minimum value 2.20 kPa, at 10 rad/s and Test Temperature, ℃	64						70					
Test on Residue from Pressure Aging Vessel (R 28)												
PAV Aging Temperature, ℃	100						100(110)					
Dynamic Shear (T 315) G*/sinδ minimum value 5000 kPa, at 10 rad/s and Test Temperature, ℃	31	28	25	22	19	16	34	31	28	25	22	19
Creep Stiffness (T 313) Stiffiness, maximum value 300 Mpa m-value, minimum value 0.30, at 60 sec and Test Temperature, ℃	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30
Direct Tension (T 314) Failure strain, minimum value 1.0%, at 1.0 mm/min and Test Temperature, ℃	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30

Table 313-4 (c): Specification for Performance-Graded Asphalt Binders (PG 76 – PG 82)

Binder Performance Grade	PG 76					PG 82				
	-10	**-16**	**-22**	**-28**	**-34**	**-10**	**-16**	**-22**	**-28**	**-34**
Design high pavement Temperature, ℃:	<76					<82				
Design low pavement Temperature, ℃:	≥10	≥16	≥22	≥28	≥34	≥10	≥16	≥22	≥28	≥140
Test on Original Binder										
Flash Point Temperature (T 48), Min., ℃	230									
Viscosity (T 316) Maximum value of 3 Pa-s at Test temperature, ℃	135									
Dynamic Shear (T 315) G*/sinδ minimum value 1.00 kPa, at 10 rad/s and Test Temperature, ℃	76					82				
Test on Residue from Rolling Thin Film Oven (T 240)										
Mass Loss, Maximum %	1.00									
Dynamic Shear (T 315) G*/sinδ minimum value 2.20 kPa, at 10 rad/s and Test Temperature, ℃	76					82				
Test on Residue from Pressure Aging Vessel (R 28)										
PAV Aging Temperature, ℃	100(110)					100(110)				
Dynamic Shear (T 315) G*/sinδ minimum value 5.000 kPa, at 10 rad/s and Test Temperature, ℃	37	34	31	28	25	40	37	34	31	28
Creep Stiffness (T 313) Stiffiness, maximum value 300 Mpa m-value, minimum value 0.30, at 60 sec and Test Temperature, ℃	0	-6	-12	-18	-24	0	-6	-12	-18	-24
Direct Tension (T 314) Failure strain, minimum value 1.0%, at 1.0 mm/min and Test Temperature, ℃	0	-6	-12	-18	-24	0	-6	-12	-18	-24

313.2.2 Aggregate

The aggregate used in production of Superpave shall meet all stated requirements in this section of the General Specification. The Contractor shall, at his own responsibility, define the source(s) and the aggregate quantities suitable for work in accordance with the requirements of this General Specifications.

The different aggregate sizes shall be stockpiled on stable clean leveled surface and in spaced heaps of not less than ten (10) meters apart or in wall-separated heaps. The aggregates shall be hauled from stockpiles locations by equipments which are approved by the Engineer. The hauling and/or stockpiling method shall not lead to pollution of the environment or aggregate or particle segregation.

The mineral filler used in Superpave shall be a product of rock powder or rock dust with plasticity index not more than 4%. It may also be of furnace slag and/or metal raw or Portland cement or hydrated lime or any other material which will satisfy the quality requirements as in AASHTO M-85 or AASHTO M-240 for Portland Cement and ASTM C-207 for hydrated lime.

313.2.2.1 Quality Requirements for Combined Aggregates

The combined aggregate shall satisfy all consensus properties shown in Table 314-5, according to the methods defined in the Table 314-7.

The source properties of the aggregate used in Superpave production shall conform to all requirements listed in Table 314-6, according to the defined test methods.

All tests listed in Tables 314-5 and 314-6 of this General Specifications shall be performed on the blended aggregate which is selected for production of Superpave concrete, except the Los Angeles Abrasion Test which may be performed on the blended aggregate or for each source / stockpile alone.

Table 313-5: Aggregate Consensus Properties Requirements

Design Traffic Volume (ESAL) (million)	Coarse Aggregates with at Least One/Two Fractured Faces (min %)		Fine Aggregate Angularity (min % air voids)		Sand Equivalent (min)	Flat and Elongated Particles at 5:1 Ratio (min)
	Layer Location from Pavement Surface*					
	<100 mm	≥100 mm	<100 mm	≥100 mm		
<0.3	55/-	-/-	-	-	40	-
0.3 to <3	75/-	50/-	40	40	40	10
3 to <10	85/80**	60/-	45	40	45	10
10 to <30	95/90	80/75	45	40	45	10
≥30	98/98	98/98	45	45	50	10

* Layer location from pavement surface is considered to be less than 100 mm if the layer is the surface layer or if quarter of its thickness lies within the upper 100 mm of the pavement surface.

** 85/80 means minimum 85% of aggregates have one fractured face and minimum 80% have two or more fractured faces.

Table 313-6: Requirements of the Aggregate Source Properties

Aggregate Properties	Test Method	Requirements
Los Angeles Abrasion	AASHTO T-96	30% (max)
Soundness (loss in Sodium Sulphate)	AASHTO T-104	12% (max)
Clay lumps and friable Particles	AASHTO T-112	0.25% (max)

Table 313-7: Test Methods for Aggregates

Aggregate Properties	Test Method
Coarse Aggregate Fractured Faces	ASTM D-5821
Fine Aggregate Angularity	AASHTO T-304 (Method A)
Sand Equivalent Test	AASHTO T-176
Flat and Elongated Particles Test	ASTM D-4791

313.2.2.2 Nominal Maximum Size

The combined aggregate shall have a nominal maximum aggregate size of 4.75 to 19.0 mm for HMA Wearing courses and no larger than 37.5 mm for HMA Base courses. Recommended nominal maximum aggregate sizes for different applications and lift thicknesses are given in Table 314-8.

Table 313-8: Recommended Aggregate Nominal Maximum Aggregate Sizes for Dense-Graded HMA Mixtures

Application	Recommended NMAS, mm	Minimum Lift Thickness, mm	
		Fine-Graded Mixtures	Coarse-Graded Mixtures
Leveling course mixtures	4.75 9.5	15 to 25 30 to 50	20 to 25 40 to 50
Wearing Course mixtures	4.75 9.5 12.5	15 to 25 30 to 50 40 to 65	20 to 25 40 to 50 50 to 65
Intermediate course mixtures	19.0 25.0	60 to 100 75 to 125	75 to 100 100 to 125
Base course mixtures	19.0 25.0 37.5	60 to 100 75 to 125 115 to 150	75 to 100 100 to 125 150
Rich base course mixtures	9.5 12.5	30 to 50 40 to 65	40 to 50 50 to 65

313.2.2.3 Gradation of Combined Aggregate

The combined aggregate of Superpave shall satisfy one of the gradation requirements shown in Tables 314-9 to 314-14 which is classified according to the nominal maximum size of the aggregate.

The percent of aggregate used in the asphalt mix shall be determined by the use of the average gradation results of five representative and independent samples taken from each stockpile and/or cold bins and/or hot bins, and at least three trials shall be performed for different gradations within the specification limits of the approved gradation for each Superpave mix in order to determine the design aggregate structure and the percentages of the different aggregate sizes.

Satisfaction of the aggregate sizes to quality and gradation requirements shall be checked whenever the source and/or method of fracture changes. The maximum nominal size shall not be greater than half the respective pavement layer thickness.

Table 313-9: Gradation of Combined Aggregates (Maximum Nominal Size is 4.75 mm)

Sieve Size (mm)	Control Points (%)	
	Minimum	Maximum
12.50	100	-
9.50	95	100
4.75	90	100
1.18	30	60
0.075	6	12

Table 313-10: Gradation of Combined Aggregates (Maximum Nominal Size is 9.5 mm)

Sieve Size (mm)	Control Points (%)	
	Minimum	Maximum
12.50	100	-
9.50	90	100
4.75	-	90
2.36	32	67
0.075	2	10

Table 313-11: Gradation of Combined Aggregates (Maximum Nominal Size is 12.5 mm)

Sieve Size (mm)	Control Points (%)	
	Minimum	Maximum
19	100	-
12.50	90	100
9.50	-	90
2.36	28	58
0.075	2	10

Table 313-12: Gradation of Combined Aggregates (Maximum Nominal Size is 19 mm)

Sieve Size (mm)	Control Points (%)	
	Minimum	Maximum
25	100	-
19	90	100
12.50	-	90
2.36	23	49
0.075	2	8

Table 313-13: Gradation of combined Aggregate (Maximum Nominal Size is 25 mm)

Sieve Size (mm)	Control Points (%)	
	Minimum	Maximum
37.5	100	-
25	90	100
19	-	90
2.36	19	45
0.075	1	7

Table 313-14: Gradation of combined Aggregate (Maximum Nominal Size is 37.5 mm)

Sieve Size (mm)	Control Points (%)	
	Minimum	Maximum
50	100	-
37.5	90	100
25	-	90
2.36	15	41
0.075	0	6

313.2.2.4 Gradation Classification

The combined aggregate gradation shall be classified as coarse-graded when it passes below the primary control sieve (PCS) control point as defined in Table 314-15. All other gradations shall be classified as fine-graded.

Table 313-15: Gradation Classification and Primary Control Sieve Sizes

Aggregate NMAS (mm)	Primary Control Sieve (mm)	PCS Control Point (% Passing)
4.75	1.18	42
9.5	2.36	47
12.5	2.36	39
19.0	4.75	47
25.0	4.75	40
37.5	9.5	47

313.2.3 Job Mix Design

Job Mix Design shall be carried out in a specialized laboratory approved by the Engineer.

Design of superior performance asphalt mix shall be in accordance with AASHTO R-35 "Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt" (latest edition) with improvements as per NCHRP Report 673. Mix Design may be carried out using HMA Tools spreadsheet (available at http://www.trb.org/Main/Blurbs/165467.aspx) to avoid errors in the design.

The Contractor shall prepare a detailed technical report about the proposed job mix formula and submit to the Engineer for approval thirty (30) days prior to commencement of asphalt mix production on site. The report shall include the source(s) of materials used in the asphalt mix production, material proportions, original test results of consensus properties, source properties required for aggregate materials which proves conformity with the specified requirements and the original test results of the designed asphalt mix in the laboratory which shall include; gradation, specific gravity for aggregate sizes, test results of the asphalt binder, grade, type and percentages of used modifiers, mixing method, plant location and test results of plant production.

313.2.3.1 Job Mix Requirements

The asphalt binder shall satisfy the quality requirements of binder and aggregates mentioned previously in this Item of Work. Dense graded asphalt mix shall also satisfy the volumetric properties shown in Table 314-16 and Table 314-17 along with other requirements of this section.

The HMA design, when compacted in accordance with AASHTO T-312 at the design number of gyrations, shall have an air void content of 4.0 ±0.5 percent.

The HMA design, when compacted according to AASHTO T-312 at 7.0 ±0.5 percent air voids and tested in accordance with AASHTO T-283 shall have a minimum tensile strength ratio of 0.80.

Table 313-16:
VMA Requirements for Standard Dense-Graded Mixtures

Aggregate NMAS (mm)	Minimum VMA[a] (%)	Maximum VMA[a] (%)
4.75	16.0 to 17.0	18.0 to 19.0
9.5	15.0 to 16.0	17.0 to 18.0
12.5	14.0 to 15.0	16.0 to 17.0
19.0	13.0 to 14.0	15.0 to 16.0
25.0	12.0 to 13.0	14.0 to 15.0
37.5	11.0 to 12.0	13.0 to 14.0

a The Engineer may select minimum and maximum values for VMA within the stated ranges. Lower values for VMA will tend to produce HMA with improved rut resistance, while higher values for VMA will tend to produce HMA with better fatigue resistance and durability.

Table 313-17: Requirements for Dust/Binder Ratio

Mix Aggregate NMAS, mm	Allowable Range for Dust/Binder Ratio, by Weight
>4.75	0.8 to 1.6
4.75	0.9 to 2.0

Job Mix Design for the following type of applications shall be prepared as per NCHRP Report 673 with the adjustments mentioned thereof for binder, aggregate and mixture.

- Reclaimed Asphalt Pavement
- Gap Graded HMA Mixtures
- Open Graded HMA Mixtures

313.2.3.2 Procedures for Acceptance of Job Mix Formula

The job mix formula furnished by the Contractor shall be revised by the Engineer and shall be accepted or returned to the Contractor for modifications within two weeks. The Contractor shall prepare once again and resubmit to the Engineer, for approval, a new job-mix formula which will satisfy the specified requirements. The Contractor shall not change sources or aggregate production methods or asphalt material mixing after approval of the job-mix except after repeat of material testing and submission of new mix.

The Engineer may take guidance from the Table 314-18 to modify the Job Mix Design within allowable range based on the site conditions for the specific project.

Table 313-18: Effect of HMA Mixture Composition on Performance of Asphalt Course

Typical effects of increasing given factor within normal specification limits while other factors are held constant within normal specification limits.

Component	Factor	Resistance to Rutting and Permanent Deformation	Resistance to Fatigue Cracking	Resistance to Low Temperature Cracking	Resistance to Moisture Damage	Durability / Resistance to Penetration by Water and Air
Asphalt Binder	Increasing High Temperature Binder Grade	↑↑↑				
	Increasing Low Temperature Binder Grade			↓↓↓		
	Increasing Intermediate Temperature Binder Stiffness		**Thick layer ↑ Thin layer ↓**			
Aggregates	Increasing Aggregate Angularity	↑↑				
	Increasing Proportion of Flat and Elongated Particles					
	Increasing Nominal Maximum Aggregate Size		↓	↓		↓
	Increasing Mineral Filler Content and/or Dust/Binder Ratio	↑↑				↑
	Increasing Clay Content				↓	
Volumetric Properties	Increasing Design Compaction Level	↑↑	↑↑			
	Increasing Design Air Void Content	↑↑				
	Increasing Design VMA and/or Design Binder Content	↓↓	↑	↓		
	Increasing Field Air Void Content	↓↓	↓↓	↓	↓↓	↓↓↓

313.3 CONSTRUCTION REQUIREMENTS

Unless otherwise stated in the Special Specifications or otherwise conflicting with what is listed in this section, the construction requirements shown in Item 203 “Asphaltic Base Course - Plant Mix” and Item 305 “Asphaltic Wearing Course - Plant Mix” shall be applied to the items related to preparation of asphalt materials, aggregates, asphalt concrete mix and joint etc.

The Contractor shall ensure surface preparation (any type) on which Superpave mix will be placed. He shall clean the surface from dust, loose material and any foreign material and apply tack coat or prime coat by the method and equipment approved by the Engineer and in accordance with the requirements listed in this General Specifications. The Contractor shall also fill the cracks and patch potholes if the surface is asphalt concrete, as shown in plans and contract documents. The central plants used in Superpave production, shall satisfy the requirements listed in the specification AASHTO M-156 designation for the "Requirements of Hot Mix Asphalt Plants”.

The Contractor shall haul, place and spread the Superpave asphalt concrete to the thickness specified in plans and by the manner and equipments stated in this General Specifications. The asphalt mix temperature during discharge from the plant into the truck shall not be less than one hundred and sixty (160) degrees Celsius and not greater than one hundred and eighty (180) degrees Celsius.

All Superpave layers shall be spread and initially compacted, in the initial coverage, in temperatures not less than one hundred and thirty five (135) degrees Celsius. All compaction works shall be finished before the mix temperature is reduced to less than one hundred and ten (110) degrees Celsius. The compaction shall be in the form of consecutive or sequential passes by approved rollers.

Longitudinal joints shall be compacted first, and then compaction may be started at the lower side towards the higher side (road center line) using self propelled steel or pneumatic rollers. The weight of each of these rollers shall not be less than ten (10) tons and the Contractor shall take care of these rollers, maintain and operate in the manner which will lead to the required purpose.

The adequate number of rollers shall be provided and the compaction shall continue till the required field density is reached. The compaction degree shall be determined on the basis of the experimental section results as in the standard method AASHTO T-310; sampling shall be done as per AASHTO T-168. The degree of compaction shall not be less than ninety three (93) percent, or more than ninety eight (98) percent of the maximum theoretical density as determined by AASHTO T-209.

313.3.1 Work Acceptance

Contractor shall apply quality control for superpave asphalt concrete production by carrying out all the required arrangements to ensure that the used materials, construction methods and the executed works achieve the quality requirements within the specification limits and tolerances as mentioned in Table 314-19 or indicated in the special specifications and other contract documents.

TABLE 313-19: Super pave Site Tolerances from approved JMF based on Standard Deviations (Mixture Composition and Gyratory Properties)

Mix Composition Property	Extraction	Nuclear Gauge	Ignition Furnace	Cold Feed
Asphalt Content	± 0.25	± 0.18	± 0.13	---
Gradation Passing 4.75 mm (No. 4) and Larger Sieves	± 3.0	--	--	± 3.0
Passing 2.36 mm (No. 8) to 150 mm (No. 100) Sieve	± 2.0	--	--	± 2.0
Passing 75 mm (No. 200) Sieve	± 0.7	--	--	± 0.7
Maximum Theoretical Specific Gravity (G_{mm})	± 0.015			

Gyratory Compacted Mix Property	
Air Voids (V_a)	± 1.0
Voids in Mineral Aggregate (VMA)	± 1.0
Voids Filled with Asphalt (VFA)	± 5.0
Bulk Specific Gravity (G_{mb})	± 0.022
Compaction Curve Slope (m)	± 0.40

The above table is applicable for individual sample. For larger sample sizes, the standard deviation values in Table 314-19 must be adjusted by the following equation:

$\square_x = \square / (n)^{0.5}$

Where:
$\square_x$ = standard deviation of sample means, of sample size "n"
$\square$ = Standard deviation from Table 314-19
n = sample size

Example:
If tolerance for mean of 3 samples is required for Air Voids then;
$\square$ = 1 (from Air Voids in Table 314-19)
n = 3 (No. of Samples)
$\square_x = 1 / (3)^{0.5} = 0.577$
Hence, tolerance for Air Voids, for mean of 3 samples = ± 0.577

The Engineer shall apply the quality assurance works by verifying that the contractor has carried out quality control procedures properly either through direct supervision of the quality control procedures or by undertaking quality assurance procedures neutrally on representative samples and with adequate numbers to judge the execution and to decide in accepting or not accepting the completed work according to the principles detailed in "Tables for Sampling and Testing Procedures" of this general specifications except otherwise specified in special specification or other contract documents.

313.3.1.1 Quality Control

The Contractor shall furnish a plan for the quality control system which he will follow during the contract period at his own expense in his laboratories, as part of the daily work follow up, or in other independent laboratories which are approved by the client, thirty (30) days prior to commencement of the asphalt concrete production for approval. The Contractor shall not start production and construction prior to obtaining written acceptance of the plan by the Engineer. He shall be committed to the plan during the contract period. That plan shall include the number, qualifications of the work staff and a list of devices, equipments, calibration methods, finished calibration certificates from approved authority, number of available tests, and number of samples, their weight and frequency.

The Contractor shall conduct the quality control tests for the materials at their source, during use, when preparing the mix design and on the site.

The total aggregate, including fine aggregate, mineral filler and asphalt binder, shall conform to the approved proportions in the job mix formula within the allowed tolerances listed in Table 314-19 of this General Specifications. When these percentages are not conforming to the approved job mix formula within the allowed tolerances, the mix production shall be suspended for recalibration.

At least two specimens from the produced asphalt mix shall be compacted by the gyratory compactor and the maximum theoretical specific density test shall be performed for each mix intended for compaction in the laboratory and according to the frequency stated in "Table for Sampling and Testing Frequencies", at the design compaction level (N_{des}) in order to ensure that the volumetric properties of the asphalt mix are within the tolerance levels as stated in Table 314-19:

313.3.1.2 Quality Assurance

The Engineer at any time has the right to assure the quality of materials and executed works through carrying out or ordering others under its direct supervision to select materials and check executed works for all or part of the quality control items specified in Article 314.3.1.1.

The Engineer has the right to review contractor's quality control records and compare these statistically with his results to insure quality. He has the right to inspect the contractor's laboratory and its equipments, its technical staff, methods of testing and construction method to insure the efficiency of the contractor's technical staff and equipments, and compliance of his inspection methods, testing and construction methods with the approved methods.

313.4 MEASUREMENT AND PAYMENT

313.4.1 Measurement

Each lot quantity of the Superpave concrete layer shall be measured in cubic meters compacted to the specified density ratio and in accordance with the thickness shown on plans. The payment shall be according to the contract unit price or the modified unit price per cubic meter for any constructed layer of asphalt concrete. No measurement shall be made for quantities and areas placed outside the allowed limits for payment

purposes. Payment and prices shall be full compensation against provision of labor, materials, equipments, tools and all other items necessary for work completion as shown in this General Specifications and Special Specifications.

Payment and deductions shall be done for Asphalt Wearing Course as per Item 305 and for Asphalt Base Course as per Item 203 of these Specifications.

Pay Item No.	Description	Unit of Measurement
313 a	Superpave Asphalt for Base Course	CM
313 b	Superpave Asphalt for Wearing Course	CM

STRUCTURES

STRUCTURES

SECTION 400 G E N E R A L

400.1 DESCRIPTION

This item contains a general description of the specific items of work, the materials, construction requirements, and methods of measurement and payment for all concrete structures including bridges, culverts, piles, composite structures of concrete such as barriers and steel, pre-stressed and post tensioned girder and all brick and stone masonry structures built as indicated on the drawings and in conformity with the lines, grade, dimension in conjunction with any instructions issued by the Engineer. Materials, equipment, workmanship and construction methods applied in the work shall conform to the requirements laid down herein and shall also follow the best modern construction practices with the approval of Engineer. This item shall also include construction of certain structural features and incidental items which are either common to all types of structures or which may apply to any of them.

400.2 CLEARING OF SITE

The contractor shall clear the sites for proposed structures of trees, bushes, stumps and debris, in the manner outlined in section 101 "Clearing and Grubbing" cost of which shall be deemed to be included in the price bid for the various items. Special clearing of site such as removal of existing bridges, buildings, concrete pavement etc., will be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with the special clearing shall be deemed to be included in the price tendered for various items of the structures in the Bill of Quantities.

Removal or relocation of public or private utilities such as optic fiber, telephone, cable lines, power lines, sewer and water pipe lines, railway tracks and their appurtenances etc., shall be arranged by the Employer's Representative with the concerned Government Agency/Agencies, Autonomous Bodies, Utility companies involved. The Employer shall bear the costs of relocating such utilities.

400.3 ALIGNMENT AND GRADE

The structures on vertical curves or the structures which have super elevated roadways because of horizontal curves and those spans on which definite finished camber is necessary in order to form a uniform grade line, all require special care and attention regarding to the elevation and alignment of their railing and kerbs.

400.4 FOUNDATION DATA

Refer to clause 400(A).3 (b)

400.5 FINAL CLEARING

Upon completion of structure, the contractor shall clean up the site, remove all temporary buildings, false work, lumber, equipment and all other debris. The contractor shall level off all excavated material not used for back fill around piers, bents, abutment, culvert, headwalls and on embankment slopes. Bridge decks and sidewalks shall be left in clean and workman like condition. No specific payment for clearing up shall be made but the cost shall be included in other items shown on the bill of quantities.

400.6 OPENING TO TRAFFIC

Bridges or slab or box culverts having decks constructed with Portland Cement concrete shall remain closed to all traffic and Contractor's equipment subject to the results of tests made of the concrete but not less than twenty eight (28) days after the placing of concrete.

The above time of opening to traffic is applicable when temperatures are above ten (10) degree C. When temperatures are below ten (10) degree C, the time of opening to traffic shall be increased at the discretion of the Engineer. In any event bridges or culverts with concrete decks shall not be opened to traffic without the approval of the Engineer.

400.7 MEASUREMENT AND PAYMENT

400.7.1 Measurement

The quantities of various pay items which constitute the completed and accepted structures shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the several pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

400.7.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labour, equipment, tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for cofferdam construction, form lumber, false work and other incidental expenses.

ITEM 400 (A) BRIDGES AND CULVERTS

400.A.1 DESCRIPTION

All steel and concrete bridges and concrete culverts shall be constructed as indicated on the plans, in conformity with the lines, grades, dimensions and design shown on the plans and in accordance with the provision of item 107 "Structural Excavation and Backfill", item 401 "Concrete", item 402 "False Work and Centering for Bridges", item 403 "Form Work", item 404 "Steel Reinforcement", and item 405 "Pre Cast Concrete Structures", and all other pay items which are to constitute the complete construction of the structure, as directed by the Engineer.

400.A.2 MATERIALS

The materials used shall be those prescribed for several contract items which are to constitute the complete structure.

400.A.3 CONSTRUCTION REQUIREMENTS

a. Clearing the Site

The contractor shall clear the site of the proposed structure of trees, bushes, stumps, and debris in accordance with section 101 "Clearing and Grubbing". Special clearing of site such as removal of existing buildings, concrete pavement shall be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with this special clearing shall be deemed to be included in the price tendered for the various items of structures in the tendered Bill of Quantities.

Removal or relocation of public or private utilities such as optic fiber, telephone or cable lines, power lines, underground cable lines, sewer and water supply lines, railway tracks and their appurtenances etc. shall be arranged by the employer representative with the specific government agency, utility companies and person involved. The Employer shall bear the cost of relocating such utilities.

b. Foundation Data

Foundation data including the location of all boreholes together with the records of ground conditions encountered have been obtained from soil investigation by test boring, test pits or other sources. It is the Engineer's responsibility to ensure by additional investigations through the contractor at the very beginning of construction work that the foundation levels given in the Drawings coincide with the local requirements.

c. Alignment and Grades

All structural members such as prefabricated girders, cast in situ deck slab, cast in situ superstructures, bridge rails including kerbs, wheel guards, safety fencing shall be so constructed and placed that finished vertical alignment and grade shall be as shown on the Drawings.

Rails, Sidewalks and Kerbs on the curved portion of structure shall be constructed, as far as possible after the completion of the entire superstructure slab. In such cases, the height of rail, sidewalk and/or kerb may vary with respect to the grade line of the slab in order to produce the desired appearance.

d. Erection Method

Before moving any construction equipment to the site, the contractor shall submit for approval an outline of the method he proposes to follow in the erection of structure.

e. Navigable Streams

The channel of navigable streams shall be kept clear for safe passage of water. The contractor shall provide and maintain all necessary light and signals in accordance with the navigation authority's requirements. The contractor shall pay due regard to the hazard of the river flow during period of intense rainfall. All material deposited in the channel shall be removed to the required depth and clearance lines at the contractor's expense.

f. Concreting

The concrete of Bridges or culverts shall be poured and surface finished and cured as per requirements conforming to item 401.3

g. Final Clearing

Upon completion of structures, the contractor shall clean up the site conforming to requirements in item 400.5

h. Public Bodies/Service Authorities

The Contractor's methodology shall meet all statutory requirements of the railway, irrigation or Service Authorities and his rates shall include for all costs of meeting these requirements.

400.A.4 MEASUREMENT AND PAYMENT

400.A.4.1 Measurement

The quantities of various pay items of Bridges and culverts which constitute the completed and accepted structures shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the several pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

400.A.4.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labour, equipment , tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for cofferdam construction, form lumber, false work and other incidental expenses.

STRUCTURES

SECTION 400 (A) BRIDGES AND CULVERTS

400.A.1 DESCRIPTION

All steel and concrete bridges and concrete culverts shall be constructed as indicated on the plans, in conformity with the lines, grades, dimensions and design shown on the plans and in accordance with the provision of item 107 "Structural Excavation and Backfill", item 401 "Concrete", item 402 "False Work and Centering for Bridges", item 403 "Form Work", item 404 "Steel Reinforcement", and item 405 "Pre Cast Concrete Structures", and all other pay items which are to constitute the complete construction of the structure, as directed by the Engineer.

400.A.2 MATERIALS

The materials used shall be those prescribed for several contract items which are to constitute the complete structure.

400.A.3 CONSTRUCTION REQUIREMENTS

a. Clearing the Site

The contractor shall clear the site of the proposed structure of trees, bushes, stumps, and debris in accordance with section 101 "Clearing and Grubbing". Special clearing of site such as removal of existing buildings, concrete pavement shall be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with this special clearing shall be deemed to be included in the price tendered for the various items of structures in the tendered Bill of Quantities.

Removal or relocation of public or private utilities such as optic fiber, telephone or cable lines, power lines, underground cable lines, sewer and water supply lines, railway tracks and their appurtenances etc. shall be arranged by the employer representative with the specific government agency, utility companies and person involved. The Employer shall bear the cost of relocating such utilities.

b. Foundation Data

Foundation data including the location of all boreholes together with the records of ground conditions encountered have been obtained from soil investigation by test boring, test pits or other sources. It is the Engineer's responsibility to ensure by additional investigations through the contractor at the very beginning of construction work that the foundation levels given in the Drawings coincide with the local requirements.

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All structural members such as prefabricated girders, cast in situ deck slab, cast in situ superstructures, bridge rails including kerbs, wheel guards, safety fencing shall be so constructed and placed that finished vertical alignment and grade shall be as shown on the Drawings.

Rails, Sidewalks and Kerbs on the curved portion of structure shall be constructed, as far as possible after the completion of the entire superstructure slab. In such cases, the height of rail, sidewalk and/or kerb may vary with respect to the grade line of the slab in order to produce the desired appearance.

d. Erection Method

Before moving any construction equipment to the site, the contractor shall submit for approval an outline of the method he proposes to follow in the erection of structure.

e. Navigable Streams

The channel of navigable streams shall be kept clear for safe passage of water. The contractor shall provide and maintain all necessary light and signals in accordance with the navigation authority's requirements. The contractor shall pay due regard to the hazard of the river flow during period of intense rainfall. All material deposited in the channel shall be removed to the required depth and clearance lines at the contractor's expense.

f. Concreting

The concrete of Bridges or culverts shall be poured and surface finished and cured as per requirements conforming to item 401.3

. Final Clearing

Upon completion of structures, the contractor shall clean up the site conforming to requirements in item 400.5

h. Public Bodies/Service Authorities

The Contractor's methodology shall meet all statutory requirements of the railway, irrigation or Service Authorities and his rates shall include for all costs of meeting these requirements.

400.A.4 MEASUREMENT AND PAYMENT

400.A.4.1 Measurement

The quantities of various pay items of Bridges and culverts which constitute the completed and accepted structures shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the several pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

400.A.4.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labour, equipment, tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for cofferdam construction, form lumber, false work and other incidental expenses.

STRUCTURES

SECTION 400 G E N E R A L

400.1 DESCRIPTION

This item contains a general description of the specific items of work, the materials, construction requirements, and methods of measurement and payment for all concrete structures including bridges, culverts, piles, composite structures of concrete such as barriers and steel, prestressed and post tensioned girder and all brick and stone masonry structures built as indicated on the drawings and in conformity with the lines, grade, dimension in conjunction with any instructions issued by the Engineer. Materials, equipment, workmanship and construction methods applied in the work shall conform to the requirements laid down herein and shall also follow the best modern construction practices with the approval of Engineer. This item shall also include construction of certain structural features and incidental items which are either common to all types of structures or which may apply to any of them.

400.2 CLEARING OF SITE

The contractor shall clear the sites for proposed structures of trees, bushes, stumps and debris, in the manner outlined in section 101 "Clearing and Grubbing" cost of which shall be deemed to be included in the price bid for the various items. Special clearing of site such as removal of existing bridges, buildings, concrete pavement etc., will be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with the special clearing shall be deemed to be included in the price tendered for various items of the structures in the Bill of Quantities.

Removal or relocation of public or private utilities such as optic fiber, telephone, cable lines, power lines, sewer and water pipe lines, railway tracks and their appurtenances etc., shall be arranged by the Employer's Representative with the concerned Government Agency/Agencies, Autonomous Bodies, Utility companies involved. The Employer shall bear the costs of relocating such utilities.

400.3 ALIGNMENT AND GRADE

The structures on vertical curves or the structures which have superelevated roadways because of horizontal curves and those spans on which definite finished camber is necessary in order to form a uniform grade line, all require special care and attention regarding to the elevation and alignment of their railing and kerbs.

400.4 FOUNDATION DATA

Refer to clause 400(A).3 (b)

400.5 FINAL CLEARING

Upon completion of structure, the contractor shall clean up the site, remove all temporary buildings, false work, lumber, equipment and all other debris. The contractor shall level off all excavated material not used for back fill around piers, bents, abutment, culvert, headwalls and on embankment slopes. Bridge decks and side walks shall be left in clean and workman like condition. No specific payment for clearing up shall be made but the cost shall be included in other items shown on the bill of quantities.

400.6 OPENING TO TRAFFIC

Bridges or slab or box culverts having decks constructed with Portland Cement concrete shall remain closed to all traffic and Contractor's equipment subject to the results of tests made of the concrete but not less than twenty eight (28) days after the placing of concrete.

The above time of opening to traffic is applicable when temperatures are above ten (10) degree C. When temperatures are below ten (10) degree C, the time of opening to traffic shall be increased at the discretion of the Engineer. In any event bridges or culverts with concrete decks shall not be opened to traffic without the approval of the Engineer.

400.7 MEASUREMENT AND PAYMENT

400.7.1 Measurement

The quantities of various pay items which constitute the completed and accepted structures shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the several pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

400.7.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labour, equipment, tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for cofferdam construction, form lumber, false work and other incidental expenses.

SECTION 401 C O N C R E T E

401.1 DESCRIPTION

This work consists of furnishing placing, curing, finishing including transport of cement concrete made from approved type of Cement, water, fine and coarse aggregates all in accordance with the requirements in these specifications and conforming to the lines, grades, and typical sections shown on the Drawings or called for in the special Provisions and to the approval of the Engineer.

401.1.1 CLASSES OF CONCRETE

The classes of concrete recognized in these specifications shall be designated: A, B, C, D1, D2, D3, Y and Lean Concrete. The Class of concrete to be used shall be as called for on the Drawings or as directed by the Engineer or specified in the Special Provisions. The following requirements shall govern unless otherwise shown on the Drawings.

Class A1 Concrete shall be used everywhere, for non-reinforced and reinforced concrete structures, except as noted below or directed by the Engineer. Concrete placed under water shall be Class A2 with a minimum cement content of three hundred fifty (350) kg per cubic meter of concrete with a slump between ten (10) and fifteen (15) cm. Concrete placed for piles shall be class A3 with a minimum cement content of four hundred (400) Kg per cubic meter.

Class B Concrete shall be used only where specified.

Class C Concrete shall be used for cribbing, or as otherwise directed by the Engineer or specified in the Special Provisions or on the Drawings.

Class D1,D2 or D3, concrete shall be used for pre-stressed and post-tensioned elements, as indicated on drawings.

Class Y concrete shall be used as a filler in steel grid bridge floors, in thin reinforced sections, or as otherwise specified in the Special Provisions.

Lean Concrete shall be used in thin layers underneath footings and when called for on the Drawings or directed by the Engineer.

The concrete of the various classes shall satisfy the requirements shown in Table 401-1

TABLE 401-1
Portland Cement Concrete Requirements

Class of Concrete	Min. Cement Kg/Cubic Meter	Max. Size of Coarse Aggregate (mm)	28 days Cylinder Compressive Strength (Min) (Kg/Sq. cm.) psi	Consistency (Range in Slump) Vibrated (mm)	Maximum Permissible Water – Cement Ratio
A_1	300	20	(210) 3000	25-75	0.58
A_2	350	25	(245) 3500	100-150	0.58
A_3	400	38	(280) 4000	100-150	0.58
B	250	51	(175) 2500	25-75	0.65
C	275	38	(210) 3000	25-75	0.58
D_1	450	25	(350) 5000	50-100	0.40
D_2	500	25	(420) 6000	50-100	0.40
D_3	550	25	(490) 7000	50-100	0.40
Y	400	13	(105) 1500	25-75	0.58
Lean Concrete	175	51	(105) 1500	–	–

401.1.2 TYPES OF CONCRETE WORKS

Under Ground Concrete

Concrete poured below Natural Surface Level with or without shuttering and shoring e.g. Piles, Pile Caps etc.

On Ground Concrete

Concrete poured by erecting formwork with necessary bracings on ground e.g. Piers, Columns, Slabs on-grade, NJ Barriers, Retaining Walls ($H \leq 3.0m$) etc.

Elevated Concrete

Concrete poured by erecting props, bracing and towers to support the formwork at higher levels e.g. Deck Slabs, Retaining Walls ($H > 3.0m$), Transoms, and Diaphragms etc.

401.2 MATERIAL REQUIREMENTS

401.2.1 Portland Cement

Cement remaining in bulk storage at the mill, prior to shipment, for more than six (6) months or cement stored in local storage by contractor for more than three (3) months after shipment from the factory may be retested before use and shall be rejected if it fails to meet any of the specification requirements.

Portland cement shall conform to the requirements of the Standard Specifications for Portland cement, AASHTO Designation M85 (ASTM Designation C150). The type of the cement to be used, unless otherwise shown on the Drawings, shall be type-I.

Sampling of cement shall be in accordance with AASHTO Designation T-127.

TABLE 401-2
General Features of the main types of Portland Cement

	Classification	Characteristics	Applications
Type I	General Purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now are.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structure exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to type I)

Mill certificates shall accompany delivery of the material to the work.

Cement shall be delivered in sufficient quantities to ensure that there is no suspension of the work of concreting at any time. Different brand or different types of cement from the same mill, or the same brand or type from different mills shall not be mixed or used alternately in the same item of construction unless authorized by the Engineer, after preparing new mix design.

401.2.2 Fine Aggregate

The fine aggregate shall consist of sand, stone screenings or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable, uncoated grains free from injurious amount of dust, lumps, soft or flaky particles, shale alkali, organic matter, material reactive with alkalis in the cement loam or other deleterious substances, and shall not contain more than three (3) percent of material passing the No.200 sieve by washing nor more than one

percent of clay lumps or one (1) percent of shale. The use of beach sand is prohibited without the written consent of the Engineer.
For exposed work, the fine aggregate shall be free from any substance that will discolour the concrete surface.

The fine aggregate shall be uniformly graded and when tested in accordance with AASHTO Designation T-11 and T-27 shall meet the following grading requirements:

TABLE 401-3
GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight.
3/8 inch	100
No. 4	95-100
No. 16	45-85
No. 50	10-30
No. 100	2-10
No. 200	0-3

In case if fine aggregates fail under Fineness Modulus or Gradation however material passing No. 4 in combined aggregate qualifies for these requirements, then the material can be accepted.

Fine aggregates shall be of such quality that mortar specimens, prepared with standard Portland cement and tested in accordance with AASHTO Designation T-71, shall develop a compressive strength at 7 days of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.3 to 3.1. Natural aggregates if required shall be thoroughly and uniformly washed before use. Sand equivalent (T-176) shall be 75 min.

For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples submitted by the Contractor from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus of greater than 0.20 either way from the fineness modulus of mix design samples submitted by the Contractor may be rejected till new trial mixes are prepared and tested by the contractor.

Testing of the aggregate is specified under Item 401.3.9 of these specifica

401.2.3 Coarse Aggregate

The coarse aggregate shall consist of crushed or broken stone, gravel or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable uncoated particles, free from injurious amount of soft, friable, thin elongated, or laminated pieces, alkali, organic or other deleterious matter and conforming to the requirements of these Specifications.

The coarse aggregate shall be of uniform grading with maximum sizes as required for the various classes of concrete as shown in Table 401-3 and when tested in accordance with AASHTO Designation T-11 & T-27 shall meet the following grading requirements.

TABLE 401-4
GRADING OF COARSE AGGREGATES

Designated Sizes	Percentage by Weight Passing Laboratory Sieves Having Square Openings, in Inches							
	2 1/2	2	1 1/2	1	3/4	1/2	3/8	No. 4
1/2-in. to No. 4	–	–	–	–	100	90-100	40-70	0-15*
3/4-in. to No. 4	–	–	–	100	90-100	–	20-55	0-10*
1 -in. to No. 4	–	–	100	95-100	–	25-60	--	0-10*
1 1/2 -in. to No. 4	–	100	95-100	–	35-70	–	10-30	0-5
1 1/2-in. 3/4 -in.	–	100	90-100	20-55	0-15	–	0-5	–
2 -in. to No. 4	100	95-100	–	35-70	–	10-30	–	0-5
2 -in. to 1-in.	100	90-100	35-70	0-15	–	0-5	–	–

* Not more than five 5 percent shall pass No.8 sieve.

Coarse aggregate shall contain not more than one (1) percent by weight of material passing the No.200 sieve by washing and not more than five (5) percent of soft fragments.

It shall have an abrasion loss of not more than forty (40) percent at five hundred (500) revolutions, when tested in accordance with AASHTO T-96.

When tested in accordance with AASHTO T-104, for five cycle, the loss with the sodium sulphate soundness test shall be not more than 12 percent.

Natural aggregates shall be thoroughly washed before use. Testing of coarse aggregate is specified under Item 401.3.9 of these Specifications.

The aggregate shall be non-alkali/silica reactive where the concrete is to be poured under water or exposed to humid conditions. In case the Contractor proposes to use the aggregate having the alkaline/siliceous characteristics with the intention to use it with Blast Furnace Slag Cement, he will under take to carry out the job with out any extra cost and shall arrange to conduct the necessary tests as directed by the Engineer.

401.2.4 Combined Aggregate

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

401.2.5 Plum/Rubble or Cyclopean Concrete

Rubble or cyclopean concrete shall consist of tough, sound, and durable rock embedded in Mass Concrete of Class B. Stone shall be of approved quality, sound and durable, and free from segregation, cracks, or imperfections tending to destroy its resistance to the weather. It shall be sharp angled, non-flaky, cubical, free from dirt, oil or any other injurious material which may prevent the proper adhesion of the mortar. In general, the percentage of wear shall not exceed fifty (50) when tested in accordance with the Standard Method of Testing for Abrasion of Coarse Aggregate by the use of the "Los Angeles Machine", ASTM C535.

The stones shall be carefully placed and shall not be dropped into place. Stone and Concrete shall be cast in alternate layers, as specified hereunder. They shall be cast

to avoid damage to the forms or to the partially set adjacent masonry. Stones shall be washed and saturated with water before placing. The stones shall not be larger than one third (1/3) of the cross section of the concrete, with a maximum size of 250mm and should not be placed closer than 150mm to each other. The volume of stones shall not exceed thirty per cent (30%) of the mass concrete volume and care shall be taken to ensure that the minimum concrete cover over any stone is 100mm.

401.2.6 Storage of Cement and Aggregates

a) All cement shall be stored, immediately upon arrival on the site of the work, in weather-proof building, which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity of a sufficient quantity of cement for at least thirty (30) days use. Bulk cement, if used, shall be transferred to elevated air tight and weather-proof bins. However, if approved, sacked cement on small jobs may be stored in the open, upon a raised platform provided that ample waterproof covering is ensured. Stored cement shall meet the test requirements at any time after storage when retest is ordered by the Engineer. At the time of use all cement shall be free flowing and free of lumps. Cement bags shall be weighed at random to check for variation.

Copies of cement records shall be furnished to the Engineer showing such detail as, the quantity used during the day run or at each part of the work. Cement held in storage for a period of over sixty (60) days, or cement which, for any reason the Engineer may suspect of being damaged, shall be subject to a retest before being used in the work.

b) The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

In order to secure greater uniformity of the concrete mix, the Engineer may require that the coarse aggregate be separated into two or more sizes. Different sizes of aggregate shall be stored in separate bins or in separate stock piles to prevent the material at the edges of the piles from becoming intermixed.

If aggregates are stored on the ground the bottom layer of aggregate shall not be disturbed or used without recleaning and as approved by the Engineer.

401.2.7 Water

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. It shall be free from oil and shall contain not more than one thousand (1,000) parts per million of chlorides nor more than one thousand three hundreds (1,300) parts per million of sulfates (SO_4). In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of more than twenty five (25) percent nor a reduction in the compressive strength of mortar at fourteen (14) days of more than five (5) percent when compared to the result obtained with distilled water.

In non-reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than two thousands (2,000) parts per million of chlorides nor more than one thousand five hundreds (1,500) parts per million of sulfates as SO_4.

In addition to the above requirements, water for curing concrete shall not contain any impurities in a sufficient amount to cause discolouration of the concrete or produce etching of the surface.

When required by the Engineer, the quality of the mixing water shall be determined by the Standard Method of Test for Quality of Water to be used in concrete, AASHTO Methods of Sampling and Testing, Designation: T 26.

401.2.8 Admixtures

Admixtures shall only be allowed to be used with written permission from the Engineer. If air-entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer, and shall conform to the requirements for each of the agents specified by the manufacturer.

401.3 CONSTRUCTION REQUIREMENTS

The manufacturing, transport, handling and placing of concrete shall conform with the requirements given hereinafter.

Unless otherwise specified, ordinary Portland cement shall be used for all types of concrete. When sulphate resisting cement or other type of cement is required, it will be specified on the Drawings/or in BOQ or ordered by the Engineer.

401.3.1 Proportioning of Concrete

All concrete shall be proportioned by weighing, except as specified herein. The proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce concrete of the required strength and consistency shall be approved by the Engineer. Such approval may be withdrawn at any time, and changes in the proportions may be required for the purpose of required workability, density, impermeability, durability and strength.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various material to be used in the batch size adopted. The required consistency shall also be shown. Such lists are subject to approval by the Engineer, and shall be posted at the mixer. The amount of water in the mix is the total amount of free water, including the free water held by the aggregates.

No concrete shall be placed in the works until the results of the twenty eight (28) days test indicate that the design proportions are satisfactory as per requirements under Item 401.3.10 "Testing of Compressive Strength". Adjustment of the proportions shall be subject to the following provisions:

a) Adjustment for variation in workability - If it is found impossible to obtain concrete of the desired workability with the proportions originally approved, the Engineer shall make such changes as are necessary.

b) Adjustment for new materials - No change in the source or character of the material shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on trial mixes.

The Contractor's attention is drawn to the time required to prepare and test trial batches and the Contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress of the work is not delayed.

401.3.2 Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcement steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall

be determined to be as dry as it is practicable to satisfy the requirements for transportation and placing of the concrete as described hereinafter.

Consistency of concrete shall be determined as specified in AASHTO T-119. The Consistency of concrete at the time of delivery shall be as shown in Table 401-1 or as designated by the Engineer.

401.3.3 Mixing Concrete

a) Mixing General

The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall be rejected.

Concrete shall be thoroughly mixed in a mixer of an approved size and type that will ensure a uniform distribution of the materials throughout the mass.

All concrete shall be mixed in mechanically operated mixers. Mixing plant and equipment for transporting and placing concrete should be arranged with an ample auxiliary installation to provide a minimum supply of concrete in case of breakdown of machinery or in case the normal supply of concrete should be disrupted. The auxiliary supply of concrete shall be sufficient to complete the casting of a section up to a construction joint.

Equipment having components made of aluminum or magnesium alloys, which would have contacted with plastic concrete during mixing, transporting or pumping of Portland cement concrete, shall not be used.

Concrete mixers shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the quantity of water used.

Materials shall be measured by weighing, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall ensure accurate measurement of each ingredient.

The accuracy of all weighing devices except that for water shall be such that successive quantities can be measured to within one (1) percent of the desired value. Cement in standard packages (bags) approved by the Engineer need not be weighed. The water measuring device shall be accurate to plus or minus half percent $\pm$ 0.50%. All measuring devices shall be subject to the approval of the Engineer. Scales and measuring devices shall be tested at the expense of the Contractor as frequently as the Engineer may deem necessary to ensure their accuracy.

Weighing equipment shall be isolated so that vibration or movement of other operating equipment do not effect the accuracy of reading. When the entire plant is running, the scale reading at cut-off shall not vary from the weight designated by the Engineer more than one (1) percent for cement, one and half (1.1/2) percent for any size of aggregate, or one (1) percent for the total aggregates in any batch.

Where volumetric measurements are authorized by the Engineer, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowances shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregates. Boxes or similar containers of the exact volume required shall be filled and struck off. Measurement by wheel barrow volumes will not be permitted.

b) Mixing at Site

Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixer shall be restored

or replaced when any part or sections is worn two and half (2.5) cms. or below than the original height of the manufacturer's design. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used.

When bulk cement is used and volume of the batch is one cubic meter or more, the scale and weigh hopper for Portland cement shall be separate and distinct from the aggregate hopper or hoppers. The discharge mechanism of bulk cement weigh hopper shall be interlocked against opening before the full amount of cement is in the hopper. The discharging mechanism shall also be interlocked against opening when the amount of cement in the hopper is underweight by more than one percent or overweight by more than three (3) percent of the amount specified.

When the aggregates contain more water than the quantity necessary to produce a saturated surface-dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.

The temperature of mixed concrete, immediately before placing, shall be not more than thirty two (32) degree C. Aggregates and water shall be cooled as necessary to produce concrete within this temperatures limit. If ice is used to cool the concrete, discharge of the mixer will not be permitted until all ice is melted.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer by means that will not result in loss due to the effect of wind, or in accumulation of cement on surfaces of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than one and half (1-1/2) minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed. In case of failure of the timing device, the Contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not repaired within twenty four (24) hours, further use of the mixer will be prohibited until repairs are made.

The first batch of concrete material placed in the mixer shall contain cement, sand, and water in excess to the requirement of mix, to ensure that the drum does not extract mortar from the mix changing its design characteristics. When mixing is to stop for a period of one hour or more, the mixer shall be thoroughly cleaned.

c) Plant Mixing

At central mixing plant, batches shall be discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from weighing hopper to the mixer drum. The mixing time shall neither be less than fifty (50) second, nor more than ninety (90) seconds.

The plastisizer, accelerator or retarder or water reducing admixture, if required, shall be fed separately at the rate recommended by the manufacture, or as established by laboratory trials.

d) Transit Mixing

Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant. The truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in case the concrete batch is poured within twenty five (25) minutes of adding water.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer, and stamped in metal on the mixer. Truck mixing shall be continued for not less than fifty (50) revolutions after all ingredients, including water, are in the drum. The mixing speed shall not be less than six (6) rpm, nor more than ten (10) rpm.

Mixing shall begin within thirty (30) minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above thirty two (32) degree C, this limit shall be reduced to fifteen (15) minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

e) Partial Mixing at the Central Plant

When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation, the mixing time at the stationary plant mixer may be reduced to thirty (30) seconds and the mixing completed in a truck mixer/agitator. The mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing.

f) Stiff Concrete Mix

For mixing concrete of zero slump to be laid by pavers, gravity mixer shall not be used. Only force mixer of moving blades shall be allowed to ensure homogenous mix.

g) Hand Mixing

Hand mixing of materials shall not be allowed in any case.

401.3.4 Hauling and Delivery of Mixed Concrete

a) Hauling

Mixed concrete may be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturer, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place.

Truck agitators shall be loaded not to exceed the manufacturer's rated capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.

Bodies of non-agitating hauling equipment shall be so constructed that leakage of the concrete mix, or any part thereof, will not occur at any time, and they shall be self-cleaning during discharge.

For zero slump concrete to by laid by paver, concrete will be allowed to be hauled in open trucks. However concrete hauled in open-top vehicles shall be protected during hauling against rain, or exposure to the sun for more than twenty (20) minutes when the ambient temperature exceeds twenty five (25) degree C.

No additional water shall be incorporated into the concrete during hauling or after arrival at the delivery point.

The rate of discharge of mixed concrete from truck mixer agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before two hundred fifty (250) revolutions of the drum or blades, whichever comes first, after the introduction of cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, a time less than one hour will be required except when retarder is used in which case it shall be one (1) hour.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, the time between the introduction of cement to the aggregates and discharge shall not exceed forty five (45) minutes.

b) Delivery

The organization supplying concrete shall have sufficient plant capacity and transportation vehicles to ensure continuous delivery at the rate required. The rate of the delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing, and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed twenty (20) minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum rehandling and without damage to the structure of the concrete.

c) Retempering

The concrete shall be mixed only in such quantities as are required for immediate use and any concrete that has developed initial set shall not be used. Concrete that has partially hardened shall not be retempered or remixed.

401.3.5 Handling and Placing Concrete

a) General

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from inside the formwork, and struts, stays and braces serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used that does not reach its final position in the forms within the time stipulated above under Item 401.3.4 "Hauling and Delivery of Mixed Concrete".

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes, and pipes for conveying concrete to the forms shall be permitted only on written authorization of the Engineer. In any case the Engineer will reject the use of equipment for concrete transportation that will allow segregation, loss of fines, or in any other way will have a deteriorating effect on the concrete quality.

Open troughs and chutes shall be of metal or metal lined; where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run; water used for flushing shall be discharged clear off the structure.

When placing operations would involve dropping the concrete more than one and half (1.1/2) meters, it shall be conveyed through sheet metal or other approved pipes. As far as practicable, the pipe shall be kept buried in the newly placed concrete. After initial set of the concrete the forms shall not be jarred and no loading of any kind shall be placed on the ends of projecting reinforcement bars.

The concrete shall be placed as nearly as possible to its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

b) Pneumatic Placing

Pneumatic placing of concrete will be permitted only if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine.

At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

c) Pumping

The placing of concrete by pumping will be permitted only if specified in the Special Provisions or if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is obtained. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

d) Placing Concrete Under Water

Concrete shall not be placed under water except where inevitable in which case approval must be sought from the Engineer and the work carried out under his

immediate supervision. In this case the method of placing shall be as hereinafter specified.

Concrete deposited under water shall be class A concrete with a minimum cement content of three hundred fifty (350) Kg per cubic meter of concrete.

The slump of concrete shall be maintained between ten (10) and fifteen (15) cm. To prevent segregation, it shall be carefully placed in a compact mass, in its final position, by means of a tremie, a bottom-dump bucket, or other approved means, and it shall not be disturbed after being placed. Water must not be allowed to flow past the fresh concrete surface.

A tremie shall consist of a tube having a diameter of not less than 25 cm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the work is completed.

When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

Dewatering may proceed when the concrete seal is sufficiently hard and strong. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, chipping or other means, which will not injure the surface of the concrete.

e) Compaction

Concrete, during and immediately after placing shall be thoroughly compacted, except lean concrete under footings and concrete deposited under water. Concrete in walls, beams, columns, etc. shall be placed in horizontal layers not more than thirty (30) centimeters thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the layers. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer, which has not taken an initial set.

The compaction shall be done by mechanical vibration. The concrete shall be vibrated internally unless special authorization of other methods is given by the Engineer or is provided herein. Vibrators shall be of a type, design, and frequency approved by the Engineer. The intensity of vibration shall be such as visibly to affect a mass of concrete with a 3 cm slump over a radius of at least half a meter. The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly

work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms and shall be applied at the point of placing and in the area of freshly placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to compact the concrete thoroughly but shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the

vibration is visibly effective. Vibration shall not be applied directly to the reinforcement or to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation and vibrators shall not be used to transport concrete neither in the forms nor in troughs or chutes.

Vibration shall be supplemented by such external vibrator as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the normal vibrators.

401.3.6 Casting Sections and Construction Joints

a) General

The concrete in each integral part of a structure shall be placed continuously, and the Contractor will not be allowed to commence work on any such part unless sufficiently inspected and approved material for the concrete is at hand, and manpower and equipment are sufficient to complete the part without interruption in the placing of the concrete.

Construction joints shall be allowed only where specified on the plans or otherwise approved. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together. When shear keys or inclined reinforcement are not provided, the concrete shall be roughened as directed. Joints in the concrete due to discontinuity of work shall be avoided as far as possible. Such joints, when necessary, shall be constructed to meet the approval of the Engineer.

When the placing of concrete is temporarily discontinued, the concrete after becoming firm enough to retain its shape, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. Where a "feathered edge" might be produced at a construction joint, as in the sloped top surface of a wing wall, an inset formwork shall be used to produce an edge thickness of not less than 15 centimeters in the succeeding layer. Work shall not be discontinued within fifty (50) centimeters of the top of any face, unless provision has been made for a coping less than 50 centimeters thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of coping.

Immediately following the discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. Care shall be exercised, during the cleaning of the reinforcing steel, not to injure or break the concrete steel bond near the surface of the concrete.

b) Slab Culverts

In general, the lean concrete below the foundation shall be placed and allowed to set before the reinforced concrete is started.

After the construction of masonry abutment walls, as specified in Special Provisions, the concrete bed plate and curtain walls shall be constructed monolithically. Construction joints in wing walls where unavoidable shall be horizontal and so located that no joint will be visible in the exposed face of the wing wall above the ground line.

c) Box Culverts

Vertical construction joints shall be at right angles to the axis of the culvert.

In general, the base slab or footings of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. In this case, suitable provision shall be made for bonding the sidewalls to the culvert base, preferably by means of raised longitudinal keys so constructed as to prevent, as far as possible, the percolation of water through the construction joint.

In the construction of box culverts one and quarter (1.1/4) meters or less in height, the sidewalls and top slab may be constructed as a monolithic unit. When this method of construction is used, necessary construction joints shall be vertical and at right angles to the axis of the culvert.

In the construction of box culverts more than one and quarter (1.1/4) meters in height the concrete in the walls shall be placed and allowed to set before the top slab is placed. In this case, appropriate keys shall be left in the sidewalls for anchoring the cover slab.

If possible, each wingwall shall be constructed as a monolithic unit. Construction joints, where unavoidable, shall be horizontal and so located that no joint will be visible in the exposed face of the wingwall above the ground line.

d) Girders, Slabs, and Columns

For simple spans, concrete shall preferably be deposited by beginning at the center of the span and working from the center toward the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. For continuous spans, where required by design considerations, the concrete placing sequence shall be shown on the plans or in the Special Provisions.

Concrete in girder haunches less than one (1) meter in height shall be placed at the same time as that in the girder stem, and the column or abutment tops shall be cut back to form seats for the haunches. Whenever any haunch or fillet has a vertical height of one (1) meter or more, the abutment or columns, the haunch, and the girder shall be placed in three successive stages; first, to lower side of haunch; second, to the lower side of the girder; and third to completion.

For haunched continuous girders, the girder stem (including haunch) shall be placed to the top of stem. Where the size of the pour is such that it cannot be made in one continuous operation, vertical construction joints shall preferably be located within the area of contraflexure.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided. The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case a special shear anchorage shall be provided to ensure monolithic action between girder and floor.

Concrete in T-beam or deck girder spans may be placed on one continuous operation or may be placed in two separate operations; each of which shall be continuous; first, to the top of the girder stems and second, to completion. In the latter case, the bond between stem and slab shall be provided by suitable shear keys or by artificially roughening the surface of the top of the girder stem. In general, suitable keys may be formed by the use of timber blocks approximately five (5) by ten (10) cm in cross-section and having a length of ten (10) cms less than the width of the girder stem. These key blocks shall be spaced along the girder stems as required, but the spacing shall be not greater than thirty (30) cms center to center. The blocks shall be removed as soon as the concrete has set sufficient to retain its shape.

Concrete in box girders may be placed in two or three separate operations. In either case the bottom slab shall be placed first. Bond between the bottom slab and stem shall be positive and mechanical. If the webs are placed separately from the top slab,

bond between the top slab and webs shall be secured in the same manner as for T-beams. Requirements for shear keys for T-beams shall also apply to box girders, except that keys need not be deeper than the depth to the top of bottom slab reinforcement.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 24 hours before the caps are placed.

When friction collars are used to support cap forms, the concrete of columns shall have been poured at least seven (7) days earlier.

Unless otherwise permitted, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until the test cylinders representing the bents have obtained the minimum compressive strength but in no case in less than seven (7) days.

e) Construction Joints

Construction joints shall be made only where shown on the Drawings or called for in the pouring schedule, unless otherwise approved by the Engineer. If not detailed on the Drawings, construction joints, also in cases of emergency shall be placed to meet the approval of the Engineer. Shear keys or reinforcement shall be used, unless otherwise specified, to transmit shear or to bond the two sections together.

Before depositing new concrete on or against concrete, which has hardened, the forms shall be re-tightened. The surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not leave loose particles of aggregate or damage concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance. When directed by the Engineer, the surface of the hardened concrete which will be in contact with new concrete shall be washed with water to ensure an excess of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and watered surfaces, including vertical and inclined surface, shall first be thoroughly covered with a coating of mortar of the same proportion of sand and cement as the class of concrete used against which the new concrete shall be placed before the grout or mortar has attained its final set.

The placing of concrete shall be carried out continuously from joint to joint. The face edges of all joints, which are exposed, to view shall be carefully finished true to line and elevation.

f) Concrete Exposed to Sea Water

Unless otherwise specifically provided, concrete for structures exposed to sea water shall be Class A. The clear distance from the face of the concrete to the nearest face of reinforcement steel shall be not less than 10 cms. The concrete shall be mixed for a period of not less than 2 minutes and the water content of the mixture shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly compacted and air pockets shall be avoided. No construction joints shall be formed between levels of extreme low water and extreme high water as determined by the Engineer. Between these levels, sea water shall not come in contact with the concrete for a period of not less than thirty (30) days. The original surface, as the concrete comes from the forms, shall be left undisturbed.

g) Concrete Exposed to Alkali Soils or Alkali Water

Where Concrete may be exposed to the action of alkaline water or soils, special care shall be taken to place it in accordance with specifications herein. Wherever possible, placing shall be continuous until completion of the section or until the concrete is at

least fifty (50) cms, above ground or water level. Alkaline water or soils shall not be in contact with the concrete during placement and for a period of at least seventy two (72) hours thereafter.

h) Protection of Concrete from Environmental Conditions

General

Precautions shall be taken as needed to protect concrete from damage due to weather or other environmental conditions during placing and curing operations.

Any concrete placed during hot weather or during cold weather shall be at the Contractor's risk and any damaged concrete shall be removed and replaced at the Contractor's expense.

ii) Rain Protection

Under conditions of rain, the placing of concrete shall not commerce or shall be stopped unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.

iii) Work in Hot Weather

Hot weather is any one of following conditions that tend to impair the quality of concrete by accelerating the rate of moisture loss and rate of hydration:

a. High ambient temperature (> 38^{o}C)
b. High concrete temperature (> 32^{o}C)
c. Low relative humidity (< 50%)
d. High wind velocity (> 4.5m/s)
e. Direct solar radiation

For concreting in such weather ACI 305 shall be complied.
Concreting shall be avoided in extremely hot weather and shall be done only in better part of the day. It should be particularly avoided in dry hot and windy weather. If wind velocity rises above 4.5 m/s, windshields shall be used.

The temperature of concrete shall not exceed thirty two (32) degree C at the time of laying, unless the Contractor incorporates in the mix a plasticiser, of a make and in proportion which he has shown by laboratory tests and full scale trial to be satisfactory, to eliminate detrimental effects of high temperature without introducing any other detrimental effect on quality.

The following may be used to keep the temperature of concrete below the above limitations:

i) Chilling of concrete water by heat exchange coils or by addition of broken ice, provided that the water shall be free from ice at the time of entry into the mixer.

ii) Cooling of coarse aggregate by watering, provided that the water content of the aggregate so cooled shall be uniform.

iii) Reclaiming of aggregate from stock piles by the tunnel method to avoid using the surface layer of the stockpile with shade and wind protection of conveyor elevating to batching plant.

iv) Night work provided that (i), (ii) and (iii) are proved inadequate or unsatisfactory in their results and providing also that the Engineer has no other reason for refusing permission for night work.

The Engineer shall have power to order the suspension of concrete production in case of not taking precautionary measures by the Contractor as mentioned above. Under no circumstances will the Contractor be entitled to receive any additional payment for complying with the requirements of this clause.

iv. Work in Cold Weather

Cold Weather is defined as the period when for more than 3 consecutive days, the following conditions exist:

1. The average daily air temperature is less than 40 ^{0}F (5 ^{0}C)
2. Air temperature is not greater than 50 ^{0}F (10 ^{0}C) for more than one half of any 24-hr period.

Cold weather concreting shall comply with ACI 306. Concreting in cold weather shall not be carried out except after written approval of the Engineer.

If concreting is necessary to be continued in cold weather for the progress & safety of structure as determined by the Engineer, all the additional measures as instructed by the Engineer shall be adopted. Under no circumstances will the Contractor be entitled to receive any additional payment for complying with the requirements of this clause.

Preparation before concreting:
All snow, ice, and frost shall be removed from the surfaces, including reinforcement, against which the concrete is to be placed. Concrete shall not be placed against frozen sub-grade / soil. Before beginning concrete placement, sub-grade shall be thawed to the depth specified by the Engineer. If necessary, the thawed material should be re-compacted.

Concrete shall not be placed around massive embedments unless such embedments are at a temperature above freezing. Formwork / Shuttering should be free from frost and ice prior to placement of concrete.

Aggregates to be used in concreting shall be thawed by approved method so that they become free from frost, ice and frozen lumps prior to starting concreting The mixing water and/or aggregates shall be heated to not less than average 70 ^{o}F (21 ^{o}C) nor more than average 150 ^{o}F (65 ^{o}C), prior to being placed in the mixer, by an approved type of heating device so that the temperature of the concrete shall not be less than as mentioned in Table 401-3, at the time of placing. Overheating of aggregates should be avoided so that spot temperatures do not exceed 212 ^{o}F (100 ^{o}C). If admixtures are used for accelerated curing, they shall be approved by the Engineer prior to use at site.

Following Water Cement Ratios shall not be exceeded for structural concrete in cold weather:

Sections having minimum dimension less than or equal to 12 in	0.45
Sections having minimum dimension more than 12in	0.50

Concrete temperature:
Placement temperature - The minimum temperature of concrete immediately after placement shall be as specified in Column 2 of Table 401-4. The temperature of concrete as placed shall not exceed the values shown in Column 2 of Table 401-4 by more than 20^{o}F (11 ^{o}C).

TABLE 401-5 Concrete Temperature

(1)	(2)	(3)
Least dimension of section, in.	Minimum temperature of concrete as placed and maintained during the protection period, °F	Maximum gradual decrease in surface temperature during any 24 h after end of protection, °F
Less than 12	55 (13 °C)	50 (28 °C)
12 to less than 36	50 (10 °C)	40 (22 °C)
36 to 72	45 (7 °C)	30 (17 °C)
Greater than 72	40 (5 °C)	20 (11 °C)

Protection temperature – Protection period shall depend on the curing temperature of concrete and shall continue for a minimum period as specified in Table 401-5, or as directed by the Engineer. Unless otherwise specified, the minimum temperature of concrete during the protection period shall be as shown in Column 2 of Table 401-4. Temperatures specified to be maintained during the protection period shall be those measured at the concrete surface, whether the surface is in contact with formwork, insulation, or air. Temperature shall be measured with a surface temperature measuring device having an accuracy of ±2 °F (±1 °C). Temperature of concrete shall be measured in each placement at regular time intervals of 12 hours.

Table 401-6 Protection Period

Type of Cement	Water / Cement Ratio	Min. Protection Period (hours) at following Curing Temperature:			
		5 °C	10 °C	15 °C	20 °C
Ordinary Portland	0.4	35	25	15	12
	0.5	50	35	25	17
	0.6	70	45	35	25
Rapid Hardening Portland	0.4	20	15	10	7
	0.5	30	20	15	10
	0.6	40	30	20	15

Termination of protection – The maximum decrease in temperature measured at the surface of the concrete in a 24-hour period shall not exceed the values shown in Column 3 of Table 401-4. These limits are not to be exceeded until the surface temperature of the concrete is within 20 °F (11 °C) of the ambient or surrounding temperatures. When the surface temperature of the concrete is within 20 °F (11 °C) of the ambient or surrounding temperature, all protection may be removed.

401.3.7 Concrete Surface Finishing/Rendering

a) General

Concrete surface finishes shall be classified as follows:
Bridge Deck Surface Finish
Sidewalk Surface Finish
Ordinary Surface Form Finish
Class 1 Surface Form Finish

The bridge deck surface finish shall be given to the surface of the bottom slabs of all box type underpass structures.

The requirements for sidewalk surface finish apply to the surface of the bottom slabs in box culverts, except that the acceptable variation from a three-meter straightedge shall be 10 mm, and brooming shall be omitted.

The ordinary surface form finish shall be the final finish applied to all surfaces after removal of forms, unless otherwise specified or called for on the drawings.

The Class 1 surface form finish shall be applied only where specified, or as required by the Engineer when the ordinary surface finish did not produce the required smooth, even surface of uniform texture and appearances.

b) Bridge Deck Surface Finish

A smooth riding surface of uniform texture, true to the required grade and cross-section, shall be obtained on all bridge roadway decks. The Contractor may use hand tools, or finishing machines or a combination of both, conforming to the requirements specified herein for finishing bridge roadway deck concrete.

Finishing of concrete placed in bridge decks shall consist essentially of compacting and striking off the surface of the concrete as placed and floating with longitudinal floats the surface so struck off.

The placing of concrete in bridge roadway decks will not be permitted until the Engineer is satisfied that the rate of producing concrete will be sufficient to complete the proposed placing and finishing operations within the schedule time, that experienced finishing machine operators and concrete finishers are employed to finish the deck, that fogging equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Finishing machines shall be set up sufficiently in advance of use to permit inspection by the Engineer during the daylight hours before each pour.

The adjustment and operation of deck finishing machines shall be verified by moving the machine over the full length of the deck section to be placed and traversing the float completely across all end bulkheads before placement of concrete is begun.

Unless adequate lighting facilities are provided by the Contractor, the placing of concrete in bridge decks shall cease at such time that finishing operations can be completed during daylight hours.

Rails for the support and operation of finishing machines and headers for hand-operated strick-off devices shall be completely in place and firmly secured for the scheduled length for concrete placement before placing of concrete. Rails for finishing machines shall extend beyond both ends of the scheduled length for concrete placement to a sufficient distance that will permit the float of the finishing machine to fully clear the concrete to be placed. Rails or headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of false work, as required to obtain a bridge roadway deck true to the required grade and cross-section. Rails or headers shall be of a type and shall be so installed that no springing or deflection will occur under the weight of the finishing equipment and shall be so located that finishing equipment may operate without interruption over the entire bridge roadway deck to be finished.

Rails or headers shall be adjusted as necessary to correct for unanticipated settlement or deflection, which may occur during finishing operations.

Should settlement or other unanticipated events occur, which in the opinion of the Engineer would prevent pouring of bridge deck conforming to the requirements of these specifications, placing of deck concrete shall be discontinued until corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided prior to initial set of the concrete in the effected area, the placing of concrete shall be discontinued and a bulkhead installed at a location determined by the Engineer. All concrete in place beyond the bulkhead shall be removed.

Unless otherwise permitted by the Engineer, bridge deck concrete shall be placed in a uniform heading approximately parallel to the bridge pier or bent caps. The rate of placing concrete shall be limited to that which can be finished before the beginning of

initial set except that concrete for the deck surface shall not be placed more than three (3) meters ahead of strick off.

After the concrete has been placed, compacted, and consolidated, the surface of the concrete shall be carefully struck off by means of a hand-operated strick board operating on headers, or by a finishing machine operating on rails. A uniform deck surface true to the required grade and cross-section shall be obtained.

Following strike off, the surface of the concrete shall be floated longitudinally. In the event strike-off is performed by means of a hand-operated strike board, two (2) separate hand-operated float boards for longitudinal floating shall be provided. The first float shall be placed in operation as soon as the condition of the concrete will permit and the second float shall be operated as far back of the first float as the workability of the concrete will permit.

In the event the strike off is performed with a finishing machine, longitudinal floating of the concrete shall be performed by means of a hand-operated float board or a finishing machine equipped with a longitudinal wooden float. The longitudinal wooden float on the finishing machine shall have a length of not less than two and half (2.5) meters nor more than three and half (3.5) meters. When both strike off and longitudinal floating are to be performed by finishing machines, one machine, with operator, shall be used for strike off and a second machine, with a second operator, shall be used for longitudinal floating. Longitudinal floating may be performed with the same finishing machine that is used for strike off provided that the length of deck unit being placed is not more than 10 meters and the strike off operation is completed for said deck unit before the condition of the concrete requires that longitudinal floating be started.

Finishing machines used for strike off having a wheel base 1.8 meters or less shall be followed by 2 separate hand-operated float boards for longitudinal floating. All the provisions in this Item pertaining to hand-operated float boards shall apply to the 2 separate float boards for longitudinal floating.

Longitudinal floats, either hand-operated or machine-operated, shall be used with the long axis of the float parallel to the center line of the bridge roadway. The float shall be operated with a combined longitudinal and transverse motion planing off the high areas and floating the material removed into the low areas. Each pass of the float shall lap the previous pass by one-half the length of the float. Floating shall be continued until a smooth riding surface is obtained.

In advance of curing operations, the surface of the concrete shall be textured by brooming with a stiff bristled broom or by other suitable devices, which will result in uniform scouring. The operation shall be performed at a time and in a manner to produce a hardened surface having a uniform texture.

Hand-operated float boards shall be from three and half (3.5) to five (5) meters long, ribbed and trussed as necessary to provide a rigid float and shall be equipped with an adjustable handle at each end. The float shall be wood, not less than two and half (2.5) cms thick and from ten (10) cm to twenty (20) cm wide. Adjusting screws spaced as not to exceed 60 cms on centers shall be provided between the float and the rib. The float board shall be maintained free of twist and true at all times.

Hand-operated float boards shall be operated from transverse finishing bridges. The finishing bridges shall span completely the roadway area being floated & a sufficient number of finishing bridges shall be provided to permit operation of the floats without undue delay. Not less than two (2) transverse finishing bridges shall be provided when hand-operated float boards are used. When a finishing machine is used for longitudinal floating, one finishing bridge equivalent to the transverse finishing bridge specified herein shall be furnished for use by the Engineer.

All finishing bridges shall be of rigid construction and shall be free of excessive wobble and springing when used by the operators of longitudinal floats and shall be easily moved.

Immediate following completion of the deck finishing operations, the concrete in the deck shall be cured as specified in Item 401.3.8 "Curing Concrete" hereinafter.

The finished surface of the concrete shall be tested by means of a straightedge three (3.0) meters long. The surface shall not vary more than three (3) mm from the lower edge of the straightedge. All high areas in the hardened surface in excess of three (3) mm as indicated by testing shall be removed by abrasive means. After grinding by abrasive mean has been performed, the surface of the concrete shall not be smooth or polished. Ground areas shall not be of uniform texture and shall present neat and approximately rectangular patterns.

Where the concrete of the bridge deck is to be covered by bituminous surfacing, earth, or other cover, two and half 2.5 cms or more in thickness, the surface of the concrete shall not vary more than nine (9) mm from the lower edge of the three (3) meter straightedge.

Bridge deck surfaces under the curbs, railings and sidewalk shall be struck off to the same plane as the roadway and left undisturbed when future widening is shown on the plans.

c) Sidewalk Surface Finish

After the concrete has been placed it shall be compacted and the concrete shall be struck off by means of a strike board, floated with a wooden or cork floating and finished with a broom. An approved edging tool shall be used on all edges and at all expansion joints. Brooming shall be transverse to the line of traffic and if water is necessary, it shall be applied to the surface immediately in advance of brooming. The surface shall not vary more than six (6) mm under a three-meter straightedge, and the finished surface shall be free of blemishes.

d) Ordinary Surface Form Finish

Ordinary surface finish shall consist of filling holes or depressions in the surface of the concrete, repairing all rock pockets, removing stains and discolouration visible from traveled ways. Ordinary surface finish shall be applied to all concrete surfaces either as a final finish or preparatory to the Class 1 finish. On surfaces, which are to be buried underground or surface, which are enclosed, such as the cells of box girders; the removal of fins will not be required.

Except as provided herein, all form bolts and any metal placed for the convenience of the Contractor shall be removed to a depth of at least two and half (2.5) cms below the surface of the concrete. All rock pockets and other unsound concrete shall be removed. The resulting holes or depression shall be cleaned and filled with mortar. Form bolts projecting into the cells of box girders need not be removed unless permanent access is provided into the cells, in which case such bolts shall be removed flush with the surface of the concrete. Mortar used to fill bolt holes shall consist of one part cement and two parts sand. Other depressions and pockets shall be filled with either packed mortar or air blown mortar as directed by the Engineer. Mortar shall be cured in conformance with the requirements in Item 401.3.8 (c) "Curing Structures".

If rock pockets or holes in the opinion of the Engineer, are of such an extent or character as to affect the strength of the structure materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the portions of the structure affected.

e) Class 1 Surface Form Finish

Class 1 surface finish shall consist of finishing the surfaces of the structure as necessary to produce even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections. The degree of care in building forms and character of materials used in form work will be a contributing factor in the amount of additional finishing required to produce even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections, and the Engineer shall be the sole judge in this respect.

After completion of the ordinary surface finish, areas which do not exhibit the required smooth, even surface of uniform texture and appearance shall be sanded with power sanders or other approved abrasive means until smooth, even surfaces of uniform texture and appearance are obtained. The use of power carborundum stones or disks will be required to remove bulges and other imperfections.

Class 1 surface finish shall not be applied until a uniform appearance can be obtained.

Class 1 surface finish may be required to be applied as the final finish for the following surfaces, unless otherwise directed by the Engineer:

i) All form finish surfaces of bridge super-structures, except the under surfaces between girders and the inside vertical surfaces of T girders.

ii) All surfaces of bridge piers, columns and abutments, and retaining walls above finished ground and to at least three tenth (0.3) meter below finished ground.

iii) All surfaces of open spandrel arch rings, spandrel columns and abutment walls.

iv) All surfaces of pedestrian under crossings, except floors and surfaces to be covered with earth.

v) Surface above finished ground of culvert headwalls, end walls and retaining walls.

vi) Surface inside of culvert barrels having a height of one and half (1.5) meters or more for a distance inside the barrel at least equal to the height of the culvert.

vii) All surfaces of railings.

f) Surface Rendering

All faces of concrete which are to come in contact with back fill or pavement materials, shall be applied two coats of hot bitumen of approved quality, before placing any material around concrete.

401.3.8 Curing Concrete

a) General

All newly placed concrete shall be cured in accordance with these specifications, unless otherwise directed by the Engineer.

b) Method of Curing

The curing method shall be one or more of the following as described hereinafter.

Water Method
Curing compound Method
Reinforced Waterproof Paper Method if required by the Engineer.
Forms-in-Place Method

Steam Method
Polyethylene Sheeting Method

Water Method

The concrete shall be kept continuously wet by the application of water for a minimum period of seven (7) days after the concrete has been placed.

Cotton mats, burlaps, rugs, carpets, or earth or sand blankets, may be used as a curing medium to retain the moisture, the entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. The moisture from the nozzle shall not be applied under pressure directly upon the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period the concrete surface shall be cleared of all curing mediums.

When concrete bridge decks and flat slabs are to be cured without the use of a moisture retaining medium, the entire surface of the bridge deck or slab shall be kept damp by the application of water with an atomizing nozzle as specified in the preceding paragraph until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for a period of not less than seven (7) days.

Curing Compound Method

Surfaces exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer. For concrete having water-cement ratio of less than 0.50, water curing shall be performed for an initial period of 3 days and then curing compound shall be applied.

The membrane-forming compound used shall conform to ASTM C-309 and shall be a practically colourless liquid. The use of any membrane forming compound that will alter the natural colour of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film, and shall be of such character that it will harden within 30 minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay in the application of curing
compound, which results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under "Water Method", shall be started immediately and shall be continued until application of the compound which shall not be applied over any free standing water surface. Should the film of compound be damaged from any cause before the expiration of seven (7) days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compounds shall not hard settle in storage. They shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within one hundred twenty (120) days after the date of manufacture, the Engineer may require additional testing before use to determine compliance to requirements.

An anti-settling agent or combination of anti-settling agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located at the job-site. On-site storage tanks shall have a permanent system designed to completely re-disperse any settled material without introducing air or any other foreign substance. Containers shall be well sealed with ring seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be labeled with the manufacturer's name, specification number, batch number, number of gallons, and date of manufacture, and shall have a label warning concerning flammability. The label shall also warn that the curing compound shall be well stirred before use. When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required herein for container labels.

Curing compound may be sampled by the Engineer at the source of supply and at the job-site.

Reinforced Waterproof Paper Method

The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed, until the concrete has set, after which the waterproof paper shall be placed. The paper shall remain in place for a period of not less than 72 hours.

Reinforced waterproof paper shall comply with ASTM C 171 specifications. It shall be composed of two sheets of Kraft paper cemented together with a bituminous adhesive and reinforced with fibre. The waterproof paper shall be formed into sheets of such width as to provide a complete cover of entire concrete surface.

All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have minimum lap of ten (10) cm.

The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within seventy two (72) hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.

Sections of sheets, which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete shall not be used.

Forms-in-Place Method

Formed surfaces of concrete may be cured by retaining the forms-in-place. The forms shall remain in place for a minimum period of seven (7) days after the concrete has been placed, except that for members over five (5) cms in least dimension, the forms shall be in place for a minimum period of five (5) days. Wooden forms shall be kept wet by watering during the curing period.

Steam Method

Curing with steam method shall comply with ACI-517.2R-1992. After placing and vibrating, the concrete shall be allowed to attain its initial set before steam is applied. During the placing of concrete and application of steam, provision shall be made to prevent surface drying by means of a coating of approved material.

Sufficient steam jets or steam entry points shall be provided to ensure that the temperature between any two points adjacent to the concrete mass is not more than 10℃. The Contractor shall provide evidence that this requirement is met. Steam jets

shall not be allowed to impinge upon any part of the concrete mass, test specimens, formwork or moulds, nor shall steam delivery piping be attached directly to any formwork or moulds in such a manner that may cause localised overheating of the concrete mass.

Steam Curing Cycle

During the period prior to which steam curing is started, the temperature at the surface of the concrete mass shall not exceed 30°C.

Steam curing of concrete shall be started with the following delay, after placement of concrete:

Table 401-7: Delay before Start of Curing

Curing Temperature (°C)	Delay before start of Curing (hours)
38	2
54	3
74	5
85	6

The maximum rate of air temperature rise/fall under the steam covers shall be 11°C/h for large units and up to 33°C/h for small units. The maximum air temperature within the steam enclosure shall not exceed 70°C.

The total curing cycle (exclusive of delay period) shall preferably not be more than 18 hours. If 75% of the target 28 day compressive strength has not been achieved at the end of the curing cycle, curing by either water or steam methods, as directed by the Engineer, shall continue until that strength is reached.

Steam covers shall not be removed until the surface temperature of the concrete has fallen to within 20 °Cof the ambient air temperature outside the steam covers. Steam covers shall remain in place longer if the concrete product shows signs of damage due to thermal shock or differential cooling. Additional water curing, if required, shall not be applied until the concrete mass has cooled to the ambient air temperature, nor shall it be delayed beyond this time.

Polyethylene Sheeting Method

The wet surface of fresh concrete shall be covered with white polyethylene sheeting as soon as possible without marring the surface and should cover all exposed surfaces of the concrete. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Adjoining sheets shall overlap not less than thirty (30) cms. and the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer to provide an air-tight cover.

c) Curing Structures

All newly placed concrete for cast-in-place structures, other than highway bridge decks, shall be cured by the water method, the forms-in-place method, or, as permitted herein, by the curing compound method, all in accordance with the requirements in Item 401.3.8 (b), "Methods of Curing".

The curing compound method may be used on concrete surfaces which are to be buried underground, and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform colour is not required and which will not be visible from any public traveled way.

The top surface of highway bridge decks shall be cured by both the curing compound method, and by the water method. The curing compound shall be applied

progressively during the deck finishing operation immediately after finishing operations are completed on each individual portion of the deck. The water cure shall be applied not later than four (4) hours after completion of the deck finishing or, for portions of the decks on which finishing is completed after normal working hours, the water cure be applied not later than 8.00 a.m. the following morning.

When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surfaces being cured by the curing compound method or by the forms-in-place method, until the Engineer determines that a cooling effect is no longer required.

d) Curing Precast Concrete Members

Precast concrete members shall be cured for not less than seven (7) days by the water method or by steam curing for a period in which 80% of strength achieved, at the option of the Contractor. Steam curing for precast members shall conform to the following provisions:

After placement of the concrete, members shall be held for a minimum four (4) hours pre-casting period.

To prevent moisture loss on exposed surfaces during the pre-steaming period, members shall be covered immediately after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of the tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

Steam at jets shall be low pressure and in a saturated condition. Steam at jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed twenty (20) degree C per hour. The curing temperature throughout the enclosure shall not exceed sixty five (65) degree C and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per sixty (60) meters of continuous bed length will be required for checking temperature.

Curing of precast concrete will be considered completed after a termination of the steam curing cycle.

e) Curing Precast Concrete Piles

All newly placed concrete precast piles, both conventionally reinforced and prestressed shall be cured by the "Water Method" as described in Item 401.3.8(b) except that the concrete shall be kept under moisture for at least fourteen (14) days. At the option of the Contractor steam curing may be used in which case the steam curing provisions in Item 401.3.8(b) "Curing Precast Concrete Members" shall apply except that the concrete shall be kept wet for at least seven (7) days including the holding and steaming period.

401.3.9 Testing of Aggregates

Samples of fine and coarse aggregate to be used shall be selected by the Engineer. It shall be the responsibility of the Contractor to designate the source or sources of aggregate and to obtain the necessary samples and submit them for testing at least thirty (30) days before actual concreting operations are to begin.

Samples of aggregates shall be obtained and tested in accordance with the following standard AASHTO methods:-

i)	Sampling aggregates	T-2
ii)	Sieve analysis	T-27
iii)	Amount of material passing the No.200 sieve.	T-11
iv)	Organic impurities	T-21
v)	Mortar Strength	T-71
vi)	Sodiumsulphate soundness	T-104
vii)	Friable particles	T-112
viii)	Abrasion loss	T-96
ix)	Specific Gravity	T-84
x)	Absorption.	T-85
xi)	Production of Plastic Fines.	T-210
xii)	Fineness Modulus	T-27
xiii)	Sand Equivalent	T-17
xiv)	Potential Reactivity of Carbonate Rocks for Concrete Aggregate (Rock Cylinder Method).	ASTM C 586
xv)	Potential Alkali Reactivity of Cement -Aggregate Combinations (Morta-Bar Method).	ASTM C 227
xvi)	Potential Reactivity of Aggregates (Chemical Methods)	ASTM C 289

No aggregate for testing during the production of concrete shall be sampled at the discharge gates of the bins feeding the weight hopper. The Contractor, at his expense, shall provide safe and suitable facilities for obtaining the samples. No concreting work on the project will be permitted until the Engineer signifies in writing his approval, following the performance of the necessary tests, on all the materials involved in making concrete.

401.3.10 Testing of Compressive Strength

Concrete compressive strength requirements consist of a minimum strength at the age of twenty eight (28) days and the minimum strength which must be attained before various loads or stresses are applied to the concrete. The various strengths required are specified in Table 401-1.

The compressive strength of concrete will be determined from test cylinders, which have been fabricated from concrete sampled and tested in accordance with AASHTO T 23 and AASHTO T 22.

A set of six (6) cylinders shall be taken from each fifty (50) cubic meters of each class of concrete or fraction thereof placed each day, three (3) of the six (6) cylinders to be tested after seven (7) days and three (3) after twenty eight (28) days.

a) The minimum average 28 days test result of all samples tested at any time shall be the specified twenty eight (28) days strength.

b) No individual samples tested after 28 days shall show a test result lower than eighty five (85) percent of the required twenty eight (28) days.

Concrete represented by any single test cylinders that fails to comply with the requirement under (b) above will be rejected unless the Contractor at his expense, provides evidence that the strength and quality of the concrete placed in the work are acceptable. If such evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in accordance with the specifications of AASHTO T-24.

Test results of the cores shall meet the following requirements:-

a) Average test result of the cores shall be less than the minimum required twenty eight (28) days strength.

b) No individual core shall show a strength less than Ninety five (95) percent of the required twenty eight (28) days strength.

Should the above test results fail to comply with the requirements, concrete of that particular pour shall be rejected and removed as directed by the Engineer. Further more contractor shall redesign the concrete mix for approval of the Engineer.

In case, seven (7) days strength shows less than seventy (70) percent of the twenty eight (28) days strength (in case of type-I cement), Engineer may stop further work on that particular portion of concrete, unless twenty eight (28) days strength gives satisfactory results.

Trial Batches for Mix Productions

The placing of concrete shall not begin until trial batches of the mix design to be used have been produced by the Contractor and tested and approved by the Engineer. The trial mix proportions shall be such that the average strength of five (5) consecutive test cylinders shall be 20% higher than the specified twenty eight (28) days strength and no individual test cylinder shall be below the specified strength.

When concrete compressive strength is specified as a prerequisite to applying loads or stresses to a concrete structure or member, test cylinders will be cured under conditions similar to those at the casting site. The compressive strength of concrete determined for such purposes will be evaluated on the basis of individual tests.

401.4 MEASUREMENT AND PAYMENT

401.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters of concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes and conduits, etc., in case where their cross-sectional areas exceed 500 square centimeters.

The measurement shall not include any concrete used in the construction of cofferdams or falsework.

The volume involved in fillets, scorings, or chamfers ten square centimeters in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for.

Concrete for railings, pipe culverts, etc., is not to be measured under this item, but under separate items.

401.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below that as per shown in the Bill of Quantities which prices and payment shall be full compensation also for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

Pay Item No.	Description	Unit of Measurement
401 a	Concrete (Class A_1) 3000psi (210kg/cm2) with maximum coarse aggregate size 20mm with batching plant with Limestone aggregate	
	i. Under Ground	CM
	ii. On Ground	CM
	iii. Elevated	CM
401b	Concrete (Class B) 2500psi (175kg/cm2) with maximum coarse aggregate size 51mm with machine mixer	CM
401c	Concrete (Class C) 3000psi (210kg/cm2) with maximum coarse aggregate size 38mm with batching plant with Limestone aggregate	
	i. Under Ground	CM
	ii. On Ground	CM
	iii. Elevated	CM
401 d	Concrete (Class D_1) 5000psi (350kg/cm2) with maximum coarse aggregate size 25mm with batching plant with limestone aggregate	CM
401 e	Concrete (Class D_2) 6000psi (420kg/cm2) with maximum coarse aggregate size 25mm with batching plant with Limestone aggregate	CM
401 f	Lean concrete 1500psi (105kg/cm2) with maximum coarse aggregate size 51mm with machine mixer	CM
401 g	Concrete (Class Y) 1500 psi (105 kg/cm2) with maximum coarse aggregate size 13 mm with machine mixer with approved local aggregate	CM
401 h	Pre cast concrete (Class A_1) 3000psi (210kg/cm2) with maximum coarse aggregate size 20mm with machine mixer with approved local aggregate	CM
401 i	Concrete (Class A_2) 3500psi (245kg/cm2) with maximum coarse aggregate size 25mm with batching plant with lime stone aggregate	
	i. Under Ground	CM
	ii. On Ground	CM
	iii. Elevated	CM

401 j	Concrete (Class A_3) 4000psi (280kg/cm2) with maximum coarse aggregate size 38mm with batching plant with limestone aggregate	
	i. Under Ground	CM
	ii. On Ground	CM
	iii. Elevated	CM
401 k	Pre cast concrete (Class A_3) 4000psi (280kg/cm2) with maximum coarse aggregate size 38mm with machine mixer with limestone aggregate	CM
401 l	Pre cast concrete (Class B) 2500psi (175kg/cm2) with maximum coarse aggregate size 51mm with machine mixer	CM
401 m	Pre cast concrete (Class D_1) 5000psi (350kg/cm2) with maximum coarse aggregate size 25mm with machine mixer with limestone aggregate	CM
401 n	Pre cast concrete (Class D_2) 6000psi (420kg/cm2) with maximum coarse aggregate size 25mm with machine mixer with limestone aggregate (Specs # 401.1)	CM
401 o	Pre cast concrete (Class D_3) 7000psi (490kg/cm2) with maximum coarse aggregate size 25mm with machine mixer with limestone aggregate.	CM
401 p	Plum Concrete (20:80 concrete stone ratio) as per detailed specification and drawings	CM
401 q	Plum Concrete (30:70 concrete stone ratio) as per detailed specification and drawings	CM
401 r	Plum Concrete (40:60 concrete stone ratio) as per detailed specification and drawings	CM

SECTION 402 FALSEWORK AND CENTERING FOR BRIDGES.

402.1 DESCRIPTION

This work shall consist of the design, supply and construction of falsework (Shuttering and Scaffolding etc.) which will provide the necessary rigidity to support the loads imposed, and produce a structure, finished to the lines and grades indicated on the plans or as required by the Engineer.

402.2 MATERIAL REQUIREMENTS

Shuttering is supposed to be made of steel or approved plywood. Timber and lumber may be allowed by the Engineer to be used for falsework, shall be of sound lumber and comply with the requirement in AASHTO M 168.

Structural steel to be used for falsework shall comply with the requirements of Standard Specifications for Structural Steel AASHTO M 183. Reinforcing steel if it is to be used for falsework shall comply with the requirements of AASHTO M 31 - 82. Concrete when used shall conform to Item 401 of these specifications.

402.3 CONSTRUCTION REQUIREMENTS

402.3.1 False work Design and Drawings

Detailed working drawings and backup calculations of the falsework shall be furnished by the Contractor to the Engineer. No false work construction shall start until the Engineer has reviewed and approved the drawings. The Contractor shall provide sufficient time for the Engineer to complete this review. Such time shall be proportionate to the complexity of the false work design and in no case shall be less than one (1) week.

The Contractor may revise the falsework drawings at any time provided sufficient time is allowed for the Engineer's review before construction is started on the revised portions.
Assumptions used in design of the falsework shall include but not be limited to the following:-

i) For designing false work and centering, a weight of 2,400 kg. per cubic meter shall be assumed for green concrete. All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Engineer may require the Contractor to employ screw jacks or approved wedges to take up any settlement in the formwork either before or during the placing of concrete.

ii) The entire superstructure cross-section, except railing, shall be considered to be placed at one time, except when in the opinion of the Engineer, a portion of the load is carried by girders previously cast and having attained a certain strength.

iii) Falsework, which cannot be founded on a satisfactory footing, shall be supported on piling, which shall be spaced, driven, and removed in an approved manner. The loading used on timber piles shall not exceed the bearing value for the piles and in no case exceed ten (10) tons per pile.

iv) Soil bearing values and soil conditions (wet and dry) shall be designated by the Contractor on the falsework drawings. Falsework footings shall be designed to carry the loads imposed upon them without exceeding estimated soil bearing values or allowable settlements.

v) Falsework shall be set to give the finished structure, the camber specified or indicated on the Drawings.

vi) Arch centering shall be constructed according to the approved centering plans. Provisions shall be made by means of suitable wedges, sand boxes, or other devices for the gradual lowering of centers to render the arch self-supporting. When directed, centering shall be placed on approved jacks in order to take up and correct any slight settlement, which may occur after the placing has begun.

vii) The maximum loading and deflections used on jacks, brackets, columns, and other manufactured devices shall not exceed the manufacturer's recommendations. If requested by the Engineer, the Contractor shall furnish catalogues or other data verifying these recommendations.

viii) If the concrete is to be pre-stressed, the falsework shall be designed to support any increased or readjusted loads caused by the pre-stressing forces.

ix) Joints supporting slabs and overhangs shall be considered as falsework and designed as such.

For the construction of falsework over and adjacent to road ways where falsework openings are required for maintaining traffic, the Contractor shall provide any additional features for the work needed to ensure that the falsework will be stable if subjected to impact by vehicles.

The falsework design at the locations where said openings are required shall include but not be limited to the following minimum provisions:

i) Each exterior stringer in a span shall be securely anchored to the falsework cap or framing.

ii) Adequate bracing shall be used during all stages of falsework construction and removal over or adjacent to public traffic.

iii) Falsework members shall be at least thirty (30) cms clear of temporary protective railing members.

The falsework drawings shall include a superstructure placing diagram showing proposed concrete placing sequence and construction joint location, except that where a schedule for placing concrete is shown on the contract plans, no deviation will be permitted therefrom unless approved in writing by the Engineer.

The falsework drawings shall show any pedestrian openings, which are required through the falsework.

Anticipated total settlements of falsework and forms shall be indicated by the Contractor on the falsework drawings. These should include falsework footing settlement and joint take-up. Anticipated settlements over two (2) cms will not be allowed unless otherwise permitted by the Engineer. Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.

Detailed calculations by the Contractor showing the stresses, deflections, and camber necessary to compensate for said deflections in all load supporting members shall be included in the working drawings.

After approving the Contractor's falsework deflection camber, the Engineer will furnish to the Contractor the amounts of camber necessary to compensate for vertical alignment or anticipated structure deflection, if this is not shown on the drawings. The total camber used in constructing falsework shall be the sum of the afore mentioned cambers.

402.3.2 **<u>False work Construction and Drawings</u>**

The falsework shall be constructed to conform to the falsework drawings. The materials used in the falsework construction shall be of the quantity and quality necessary to withstand the stresses imposed. The workmanship used in falsework construction shall be of such quality that the falsework will support the loads imposed on it without excessive settlement or take-up beyond that shown on the falsework drawings.

Falsework shall be founded on footings, capable of supporting the loads imposed on it.

When falsework is supported on piles, the piles shall be driven to a bearing value, equal to the calculated pile loading as shown on the falsework drawings.

Suitable jacks or wedges shall be used in connection with falsework to set the forms to their required grade and to take up any excessive settlement in the falsework either before or during the placing of concrete.

The Contractor shall provide tell-tales attached to the soffit forms easily readable and in enough systematically-placed location to determine the total settlement of the entire portion of the structure where concrete is being placed.

Should events occur, including settlements that deviate more than + 2 cms from those indicated on the falsework drawings, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirements of these specifications, the placing of concrete shall be discontinued until corrective measures are provided to entire satisfaction of the Engineer. In the event, satisfactory measures are not taken to correctness of excessive settlements, the Contractor shall not be relieved of responsibility for conforming to the requirements of these specifications.

402.3.3 Removing Falsework

Unless otherwise shown on the drawings, or permitted by the Engineer, falsework supporting any span of a simple span bridges shall not be released before 14 days after the last concrete, excluding concrete above the bridge deck, has been placed. Falsework supporting any span of a continuous or rigid frame bridge shall not be released before 14 days after the last concrete, excluding concrete above the bridge deck, has been placed in that span and in the adjacent portions of each adjoining span where falsework is to be released.

Falsework supporting deck overhangs and deck slab between girders shall not be released until seven (7) days after the deck concrete has been placed.

In addition to the above requirement, no falsework for bridges shall be released until the supported concrete has attained a compressive strength of at least eighty (80) percent of the required twenty eight (28) days strength.

Falsework for cast-in-place pre-stressed portions of structures shall not be released until after the pre-stressing steel has been tensioned.

All falsework materials shall be completely removed. Falsework piling shall be removed at least sixty (60) cms below the surface of the original ground or stream bed. When falsework piling is driven within the limits of ditch or channel excavation areas, the falsework piling within such areas shall be removed to atleast sixty (60) cms, below the bottom and side slopes of said excavated areas.

All debris and refuse resulting from work shall be removed and the premises left in a neat and presentable condition.

402.4 MEASUREMENT AND PAYMENT

For all concrete structures, pre-stressed concrete structures or portions thereof, no separate measurement or payment shall be made for falsework supporting such structures. All falsework costs shall be considered as included in the contract prices paid (cost/CM or LM of structural members or lump-sum) for the various items of concrete work and no additional compensation will be allowed thereof.

SECTION 403 FORMWORK

403.1 DESCRIPTION

The work shall consist of providing, erecting and removing concrete forms of sufficient strength with all necessary bracings, fasteners, etc. and in conformity with the requirements hereinafter specified.

403.2 MATERIAL REQUIREMENTS

Forms shall be of wood, metal or other approved materials and shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations.

403.3 CONSTRUCTION REQUIREMENTS

403.3.1 Formwork Design and Drawings

The Contractor shall prepare working drawings, backup calculations and material data for the form work and shutters to be submitted to the Engineer for approval unless otherwise directed.

The requirements for design of formwork are the same as described under Item 402.3.1 – Falsework Design and Drawings.

403.3.2 Formwork Construction

Concrete forms shall be constructed and maintained so as to prevent warping and the opening of joints due to the shrinkage of the lumber and shall be true to the dimensions, lines and grades of the structure and with the sufficient strength, rigidity, shape and surface smoothness as to leave the finished works true to the dimensions shown on drawings or required by the Engineer and with the surface finish as specified.

Forms for exposed surfaces shall preferably be lined with metal, plywood, or other approved material, or may with the Engineer's permission, be made of dressed lumber of uniform thickness. Forms shall be filled at all sharp corners (Minimum two (2) cms triangular fillets) and shall be given a level or draft in the case of all projections, such as girders and copings, to ensure easy removal.

Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placement. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted. Metal ties or anchorage within the forms shall be so constructed as to permit their removal to a depth of at least five(5) cms from the face without injury to the concrete.

Fitting for metal ties shall be of such design that, upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in colour. Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorages for fastening forms or form supports to concrete will not be permitted.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms, which will later be removed, shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other approved coating which will permit the ready release of the forms and will not discolour the concrete. All exposed surfaces of similar portions of a concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, colour and appearance.

Concrete shall not be deposited in the forms until all work in connection with constructing the forms has been completed, all materials required to be embedded in the concrete have been placed for the unit to be poured, and the Engineer has inspected and approved said forms and materials.

The rate of depositing concrete in forms shall be such as to prevent deflections of the forms or form panels in excess of the deflections permitted by these specifications. Maximum deflection allowed due to prop settlement is 5 mm and due to bending of shutters is 3 mm, when measured with 3 meter straight edge.

Forms for all concrete surfaces, which will not be completely enclosed or hidden below the permanent ground surface, shall conform to the requirements herein for forms for exposed surfaces. Interior surfaces of underground drainage structures shall be considered to be completely enclosed surfaces.

Formwork for concrete placed under water shall be watertight. When lumber is used, this shall be planed and tongued and grooved.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding either two (2) mm or 1/270 of the center to center distance between studs, joists, form stiffeners, form fasteners, or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications, satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

Forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods, which shall be determined, as herein specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

The shape, strength, rigidity, water-tightness, and surface smoothness of reused forms shall be maintained at all times. Any warped or bulged lumber must be resized before being reused. Forms that are unsatisfactory in any respect shall not be reused.
For narrow walls and columns, where the bottom of the form is inaccessible, the lower form boards shall be adjustable so that they may be removed for cleaning out extraneous material immediately before placing the concrete.

403.3.3 Removal of Formwork

In the determination of the time for the removal of falsework and forms, consideration shall be given to the location and character of the structure, the weather, and other conditions influencing the setting of the concrete, and the materials used in the mix.

If field operations are not controlled by beam or cylinder tests, the following periods, exclusive of days when the temperature is below five (5) degree C, for removal of forms and supports shall be used as a minimum subject to the approval of the Engineer and to the requirements of Item 402.3.3. Removing Falsework.

Arch Center	**14 Days**
Centering Under Beams	**14 Days**
Supports under Flat Slabs	**14 Days**
Floor Slabs	**14 Days**
Vertical Wall Surfaces	**24 Hours**
Columns	**24 Hours**
Side of Beams	**12 Hours**
Top Slabs R.C. Box Culverts	**14 Days**

Side forms for cast-in-place beams, girders, columns, or other members where the forms do not resist dead load, bending shall remain in place for at least forty (40) hours after placing concrete for the members. Side forms for precast members may be removed the next day after placing concrete therein.

If high early strength cement is used or by the use of additional cement, these periods may be reduced as directed.

When field operations are controlled by cylinder tests, the removal of forms, supports and housing, and the discontinuance of heating and curing (where applicable) may begin when the concrete is found to have the required compressive strength, provided in no case shall supports be removed in less than seven (7) days after placing the concrete.

All forms shall be removed, except when no permanent access is available to the cells, the forms supporting the deck of box girders and the forms in hollow abutments or piers may remain in place. Prior to completion of forming for the deck forms, the inside of box girders shall be cleared of all loose material and swept clean.

Methods of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without approval. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In general, arch centering or falsework shall be struck and the arch made self-supporting before the railing or coping is placed. This precaution is essential in order to avoid jamming of the expansion joints and variations in alignment. For filled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centers, as may be necessary to avoid jamming of the expansion joints.

Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the sequence of striking centers shall be approved by the Engineer.

403.4 MEASUREMENT AND PAYMENT

For all concrete structures, pre-stressed concrete structures, precast concrete elements or portions thereof, no separate measurement or payment shall be made for formwork supporting such structures. All formwork costs shall be considered as included in the contract prices paid (cost/CM or LM of structural members or lump-sum) for the various items of concrete work and no additional compensation will be allowed thereof.

SECTION 404 STEEL REINFORCEMENT

404.1 DESCRIPTION

This work shall consist of furnishing, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with these specifications, and in conformity with the requirements shown on the Drawings and Special Provisions or as directed by the Engineer.

404.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements hereinafter given. Test reports from approved sources shall be submitted to the Engineer for all steel reinforcement used. These reports shall show the results of chemical and physical tests made.

i) Deformed Billet-Steel Bars (Grades 40 and 60) for Concrete Reinforcement AASHTO M-31 (ASTM A-615).

ii) Deformed and Plain Stainless Steel Bars for Concrete Reinforcement ASTM A-955.

iii) Zinc-Coated (Hot Dipped Galvanized) Steel Bars for Concrete Reinforcement ASTM A-767.

iv) Steel Wire and Welded Wire Reinforcement ASTM A-1064.

v) Structural Shapes for Concrete Reinforcement ASTM A-36

Corrosion protection / corrosion resistant steel reinforcement shall be used within one (1) kilometer of coastline or in any corrosive environment where chloride ion action is likely to cause steel corrosion.

404.2.1 Epoxy Coated Steel Reinforcement

Epoxy coated steel reinforcing bars shall be used, in moderate to high corrosive environment, or where specified in the drawings.

Reinforcing bars for epoxy coating shall comply with ASTM A-615 and epoxy coating shall comply with ASTM A-775.

At least 90% of all epoxy coating thickness measurements after curing shall be 175 to 300µm for bars sizes Nos. 10 to 16 [Nos. 3 to 5] and 175 to 400µm for bar sizes Nos. 20 to 57 [Nos. 6 to 18]. A finding that more than five (5) percent of the coating thickness measurements are below 125µm shall be considered cause for rejection. The upper thickness limit shall not apply to repaired areas of damaged coating.

On average, there shall not be more than 3 holidays per meter on a coated steel reinforcing bar (holiday is a discontinuity in a coating that is not discernible to a person with normal or corrected vision.). The average applies to the full production length of a bar. A wetting agent shall be used as per Test Methods ASTM G-62 in the inspection for holidays on the coated steel reinforcing bars.

The requirements for coating continuity, flexibility and adhesion as per ASTM A-775 for epoxy coated steel reinforcing bars shall be met at the manufacturer's plant prior to shipment.

404.2.2 Stainless Steel (SS) Reinforcement

Stainless Steel Reinforcement Bars shall be used in very important structures; where highest corrosion resistance is required. SS bars shall only be used if specified in the drawings and Bill of Quantities or upon written instructions of the Engineer. The type of stainless steel shall be 304 or 316 as specified, conforming to ASTM A-955. SS bars shall have mill de-scaled and pickled surface. SS bars with mill-scale or over-pickled surface shall not be used as reinforcement.

404.2.3 Hot Dipped Galvanized (HDG) Steel Reinforcement

HDG steel reinforcement bars shall be used for moderate to high corrosion protection or where specified. HDG bars shall conform to ASTM A-767. Class-I galvanizing shall be used for higher corrosion protection. If class of corrosion protection is not specified, Class-II protection shall be provided.

404.3 CONSTRUCTION REQUIREMENTS

404.3.1 Fabrication of Bent Bars

a)Order Lists

Before materials are ordered all order lists and bending diagrams shall be furnished by the Contractor, for the approval of the Engineer. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams. Any expenses incident to the revisions of material furnished in accordance with such lists and diagrams to make it comply with the drawings shall be borne by the Contractor.

b)Storing and Surface Condition of Reinforcement

Steel reinforcement shall be stored above the surface of the ground on platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, detrimental rust, loose seals, paint, grease, oil, or other foreign materials. Reinforcement shall be free from injurious defects such as cracks and laminations. Surface seams, surface irregularities, or mill scale will not be cause for rejection, provided the minimum dimensions, cross-section area, and tensile properties of a hand-wire brushed specimen meets the physical requirements for the size and grade of steel specified.

Epoxy Coated Reinforcement
In addition to the requirements mentioned above, following precautions shall be taken in handling and storage of epoxy coated reinforcement.

Coated and uncoated steel reinforcing bars shall be stored separately.

Coated bars shall be transported and handled with care. All systems for handling coated bars shall have padded contact areas. All bundling bands shall be padded, or suitable banding shall be used to prevent damage to the coating. All bundles of coated bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles. The bars or bundles shall not be dropped or dragged.

All systems for handling the coated bars at the jobsite shall have padded contact areas.

Coated bars or bundles shall not be dropped or dragged. Coated steel reinforcing bars shall be off-loaded as close as possible to their points of placement or under the crane so that the bars can be hoisted to the area of placement to minimize re-handling.

Coated bars or bundles shall be stored above the ground on wooden or padded supports with timbers placed between bundles when stacking is necessary. Space the supports sufficiently to prevent sags in the bundles.

Long-term storage shall be minimized and material delivery shall be scheduled to suit construction progress. If circumstances require storing coated steel reinforcing bars outdoors for more than two (2) months, protective storage measures should be implemented to protect the material from sunlight, salt spray and weather exposure.

Permissible amount of damage and repair of epoxy coating shall be as follows:

1 The maximum amount of repaired damaged coating shall not exceed 1% of the total surface area in each 0.3m of the bar. This limit on repaired damaged coating shall not include sheared or cut ends that are coated with patching material. If the amount of repaired damaged coating in any 0.3m length of a coated bar, exceeds 1%, that section shall be removed from the coated steel reinforcing bar and discarded.
2 All damaged coating due to fabrication or handling (to the point of shipment) shall be repaired with patching material.
3 Repaired areas shall have a minimum coating thickness of 175 µm.
4 When coated bars are sheared, saw-cut, or cut by other means during the fabrication process, the cut ends shall be coated with patching material. Coated steel reinforcing bars shall not be flame cut.
5 Repair of damaged coating shall be done in accordance with the patching material manufacturer's written recommendations.

Hot Dipped Galvanized Reinforcement
In addition to the requirements mentioned above, following precautions shall be taken in handling and storage of HDG reinforcement.

In addition to the requirements mentioned above, following precautions shall be taken in handling and storage of HDG reinforcement.

HDG and uncoated steel reinforcing bars shall be stored separately.

HDG bars shall be transported and handled with care. All systems for handling HDG bars shall have padded contact areas. All bundling bands shall be padded, or suitable banding shall be used to prevent damage to the bars. The bars or bundles shall not be dropped or dragged.

All systems for handling the coated bars at the jobsite shall have padded contact areas.

HDG bars or bundles shall not be dropped or dragged. HDG steel reinforcing bars shall be off-loaded as close as possible to their points of placement or under the crane so that the bars can be hoisted to the area of placement to minimize re-handling.

c) Fabrication

Bent bar reinforcement shall be cold bent to the shapes shown on the drawings or required by the Engineer. Bars shall be bent around a pin having the following diameters (D) in relation to the diameter of the bar (d):

Stirrups & column tie bars	D = 4xd
Other bars having:	
d<3.5 cm (1-3/8") (No.11 bar)	D = 5xd
d>3.5 cm (1-3/8")	D = 10xd

404.3.2 Placing and Fastening

a) Protection of Material

Steel reinforcement shall be protected at all times from injury. When steel, placed in position as shown on the Drawings, has easily removable and detrimental rust, loose scale, or dust, it shall be cleaned by a satisfactory method, approved by the Engineer.

Epoxy Coated Reinforcement:
Following additional protection shall be adopted for epoxy coated reinforcement:

When placing coated steel reinforcing bars, all wire bar supports, spacers, and tying wire shall be coated with dielectric material, for example, an epoxy-coated or plastic coated material compatible with concrete which will not damage or cut the coating.

After placing, walking on coated steel reinforcing bars shall be minimized. The placement of mobile equipment shall be planned to avoid damage to the coated bars.

Placed coated bars shall be covered with opaque polyethylene or other suitable protective material if cumulative environmental exposure of the coated bars, including previous uncovered storage time, of greater than two months prior to concrete embedment is expected. Provisions shall be made for adequate ventilation to minimize condensation under the cover.

When immersion-type vibrators are used to consolidate concrete around epoxy-coated steel reinforcing bars, the vibrators shall be equipped with rubber or nonmetallic vibrator heads.

Hot Dipped Galvanized Reinforcement
Following additional protection shall be adopted for HDG reinforcement:

When placing HDG steel reinforcing bars, all wire bar supports, spacers, and tying wire shall be coated with Zinc or a dielectric material, for example, an epoxy-coated or plastic coated material compatible with concrete.

When immersion-type vibrators are used to consolidate concrete around epoxy-coated steel reinforcing bars, the vibrators shall be equipped with rubber or nonmetallic vibrator heads.

When the extent of coating damage exceeds 2% of the surface area of the coated steel reinforcing bar in any 0.3–meter length, the coated bar shall be rejected. When the extent of the damage does not exceed 2% of the surface area in any 0.3–meter length, all damaged coating discernible to a person with normal or corrected vision shall be repaired with a zinc-rich formulation complying with ASTM A-767. Repair shall be done as per instructions of the manufacturer and concreting shall not be started before repair material has completely cured.

b) Placing and Fastening

Reinforcing steel shall be accurately placed in the position shown on the Drawings and firmly held during the depositing and finishing of the concrete. Cover, the distance between the external face of the bar and the face of the finished concrete, shall be as indicated on the Drawings. Reinforcing steel bars embedded in concrete shall not be bent after they are in place. Bars shall be tied at all intersections with 16 gauge black annealed wire except that where spacing is less than 1 ft (0.3m) in each direction, alternate intersections need to be tied. All intersections shall be tied in the top mat of reinforcement placed on bridge decks and the top slabs of box culverts. Abrupt bends shall be avoided except where one steel bar is bent around the other.

Stirrups and ties shall always pass around the outside of main bars and be securely attached thereto. All reinforcing steel shall be securely held at the proper distance from

steel forms, which remain in place by means of galvanized steel bars or chairs placed on the forms. All reinforcing steel, except as mentioned above, shall be securely held at the proper distance from the forms by means of templates, concrete blocks or galvanized steel chairs. Metal chairs shall not be used against formed surfaces, which will be exposed in the finished structure after the forms are stripped. Blocks for holding reinforcement away from contact with the forms shall be precast concrete blocks of approved shape, and dimensions and shall have 16-gauge black annealed tie wires embedded in them. The precast concrete block shall have a compressive strength equal to that specified for the class of concrete to be placed in the work. Layers of bars shall be separated by approved metal chairs or bolsters.

Any broken or damaged concrete spacer blocks shall be removed before concrete is placed. The use of pebbles, pieces of broken stone or brick, metal pipe or wooden blocks as spacers will not be permitted. Reinforcing steel when placed in the work shall be free from flake rust, dirt and foreign material and before any concrete is placed, any mortar which may be adhering to the reinforcing steel shall be removed. No concrete shall be deposited until the Engineer has inspected the placing of the reinforcing steel and given permission to place the concrete. The Contractor shall allow the Engineer four hours time after the reinforcement and forms are in place to conduct the inspection. Any bar of incorrect size, length or shape shall be removed and replaced with correct bars. Any bar located or spaced incorrectly shall be relocated or spaced correctly before permission is given to place concrete and such replacements and corrections shall be at the Contractor's expense. All concrete placed in violation of these provisions shall be rejected and removed.

When formwork for casting concrete is made of uncoated steel or stainless steel, the use of galvanized steel reinforcing bars shall necessitate an electrical isolation of the galvanized steel reinforcing bars from the formwork.

c) Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted. Splicing of bars, except where shown on the drawings, will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible and with a minimum separation of not less than forty (40) times bar diameters. Not more than one third (1/3)of the bars may be spliced in the same cross-section, except where shown on the drawings. Unless otherwise shown on the Drawings, bars shall be lapped with a minimum overlap of forty (40) times the bar diameter. In lapped splices, the bars shall be placed in contact and wired together. Lapped splices will not be permitted at locations where the concrete section is insufficient to provide a minimum clear distance of one bar diameter or one and one third (1-1/3) the maximum size of coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the Drawings or if authorized by the Engineer in writing. Spiral reinforcement shall be spliced by lapping at least one and one half (1-1/2) turns or by butt welding unless otherwise shown on the Drawings. Splicing / connection of uncoated steel bars and galvanized bars shall be isolated through use of vinyl tape or other non conducting material.

d) Lapping of Bar Mat

Sheet of mesh or bar-mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The overlap shall not be less than one mesh in width.

e) Covering

The minimum covering, measured from the surface of the concrete to the face of any reinforcement bar shall, unless otherwise shown on the Drawings or directed by the Engineer, not be less than 5 cm except as follows:

Top of slab	4.0 cm
Bottom of Slab	3.0 cm
Stirrups and ties in T-beams	3.5 cm

In the footings of abutments and retaining walls the minimum covering shall be 7.5 cm. In work exposed to the action of sea water the minimum covering shall be 10 cm.

Table 404-1: Difference in Properties of Steel Bars used in Construction Industry

Sr. #	Properties	NO.	Description	Unit	M.S Bar	Deformed	Deformed	Steel
					G-40	Bar G-60	Bar G-75	Tendons
1	Chemical	i	Carbon	%	0.3	0.27	0.3	0.6-0.9
		ii	Sulphur	%	0.025	0.05	0.05	0.04
		iii	Phosphorus	%	0.025	0.05	0.05	0.04
		iv	Nitrogen	%				0.012
		v	Silicon	%	0.15-0.35			0.1-0.35
		vi	Chromium	%				
		vii	Manganese	%	0.4-1.1	<2	<2	0.5-0.9
2	Mechanical	i	Yield Strength	Ksi	32-33	60	75	
		ii	Elasticity	Ksi	27,000-30,000			
		iii	Tensile Strength	Ksi	53-55	69-109	87-119	
		iv	Elongation	%	23	>15	>13	
3	Physical	i	Boiling Point	Centigrade	1350-1550			
		ii	Density	Lbs/ft^3	480-500			

404.4 MEASUREMENT AND PAYMENT

404.4.1 Measurement

The quantity to be paid for shall be the calculated theoretical number of metric tons of reinforcement steel bars, mesh or mats as determined from the approved bar bending diagrams and incorporated in the concrete and accepted, except when reinforcement is paid for under other pay items.

The weight of plain or deformed bars or bar mat will be computed from the theoretical weight of plain round bars of the same nominal size as shown in the following tabulation:

Table 404-2: ASTM Standard Bar Weights

Bar Designation		Nominal Unit Weight	
Inch	**SI**	**Lbs. Per Foot.**	**Kg. Per Meter**
# 3	10	0.376	0.560
# 4	13	0.668	0.994
# 5	16	1.043	1.552
# 6	19	1.502	2.235
# 7	22	2.044	3.041
# 8	25	2.670	3.973
# 9	29	3.400	5.059
# 10	32	4.303	6.403
# 11	36	5.313	7.906
# 14	43	7.650	11.380
# 18	57	13.600	20.240

Clips, ties separators, and other material used for positioning and fastening the reinforcement in place and structural steel shall not be included in the weight calculated for payment under this item. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the amount specified shall be measured for payment.

When laps are made for splices, other than those shown on the Drawings or required by the Engineer and for convenience of the Contractor, the extra steel shall not be measured nor paid for.

When continuous bars are shown on the Drawings, without the splices being shown the necessary steel in the splices will be paid for on the basis of the individual bars not being shorter than twelve (12) meters.

For bent bars, the length along centre-line of bar will be paid.

404.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit prices respectively for the pay items listed below and shown in the Bill of Quantities which price and payment shall be full compensation for furnishing materials, labour, equipment and incidentals necessary to complete the item.

Pay Item No.	Description.	Unit of Measurement
404 a	Providing, fabricating, laying 40 grade deformed bar reinforcement for all kinds of RCC work in substructure and superstructure including cutting, bending, binding, wastage over-laps, cost of binding wire as per AASHTO M-31	TON
404 b	Providing, fabricating, laying 60 grade deformed bar reinforcement for all kinds of RCC work in substructure and superstructure including cutting, bending, binding, wastage over-laps, cost of binding wire as per AASHTO M-31	TON
404 c	Reinforcement (Structural shapes) as per ASTM-A-36	TON

SECTION 405 PRESTRESSED CONCRETE STRUCTURES

405.1 DESCRIPTION

This work shall consist of pre-stressing precast or cast-in-place concrete by furnishing, placing and tensioning of pre-stressing steel in accordance with details shown on the plans, and as specified in these specifications or as directed by the Engineer.

This work shall also include the furnishing and installation of any appurtenant item necessary for the particular pre-stressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.

405.2 MATERIAL REQUIREMENTS

405.2.1 Pre-stressing Reinforcement Steel

Pre-stressing steel shall be high-tensile wire conforming to ASTM Specification A-421 or AASHTO Designation M-204; strand or rope conforming to ASTM Specification A-416 or AASHTO Designation M-203 or high tensile alloy bars as follows:

High-tensile-strength alloy bars shall be stress relieved and cold stretched to a minimum of 9,100 Kg/sq.cm. After cold stretching the physical properties shall, be as follows:

I)	Minimum Ultimate tensile strength	16,570 Kg/sq.cm
ii)	Minimum yield strength, measured by the 0.7 percent extension under load method shall be not less than	9,100 Kg/sq.cm
iii)	Minimum modulus of elasticity	1.75×10^6 Kg/sq.cm
iv)	Minimum elongation in 20 bar dia meter	4 percent
v)	Diameters after rupture	(-) 0.75 mm
vi)	Diameters tolerance	(-) 0.25 mm

The steel shall be free from injurious defects and shall have a smooth surface. Material, which shows injuries defects during or prior to its installation in the work, shall be rejected.

Wire and strand shall be supplied in coils of sufficient diameter to ensure that they lie out straight.

The Engineer may call for a relaxation test on pre-stressing steel in case, he is not satisfied with the source of manufacture. Relaxation for pre-stressing steel shall be measured over a period of thousand (1000) hours stressed at seventy (70) percent of its ultimate tensile strength giving less than six (6) percent elongation.

Epoxy Coated Pre-stressing Steel:

Epoxy coated pre-stressing steel shall be used in corrosive environment where chloride ion action is likely to cause steel corrosion e.g. coastal areas, areas where de-icing chemicals are used etc. or where specified in the drawings.

Pre-stressing steel strand used for epoxy coating shall meet the requirements of ASTM A-416. Epoxy coating for pre-stressing steel shall conform to ASTM A-882.

Filled epoxy-coated strand shall have relaxation losses of not more than 6.5% after 1,000 hours, when initially loaded to 70 % of the specified minimum breaking strength of the strand, when tested under conditions as per requirements of ASTM A-416

The coating thickness after curing shall be 380 to 1140 µm. The thickness of the coating film shall be determined using a magnetic gauge or other approved methods.

The coating thickness shall be measured on the crown of each of the six outer wires at least every 2000 ft [600 m] of continuous strand. The average of the coating thickness measurements for each set of six outer wires shall be supplied to the Engineer. Records of inspection during manufacture shall also be made available when required.

The requirements for coating continuity, adhesion and bond with concrete as per ASTM A-882, for epoxy coated pre-stressing steel, shall be met at the manufacturer's plant prior to shipment.

a) Testing

All wires, strands, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be likewise identified.

All samples submitted shall be representative of the lot to be furnished.

All of the materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

The contractor shall furnish for testing the following samples selected from each lot as ordered by the Engineer. The selection of samples shall be made at the manufacturer's plant by the Engineer or his representative.

Pre-tensioning Method Samples at least 2.10 M long shall be furnished of each wire, or strand size. A sample shall be taken from each and every coil.

Post-Tensioning Method Samples of the following lengths shall be furnished:

For wires, sufficient length to make up one parallel-lay cable one and half (1.5) M long consisting of the same number of wires as the cable to be furnished. For strands, one and half (1.5) M length shall be furnished.

For bars to be furnished with threaded ends and nuts, one and half (1.5) M between threads at ends.

Anchorage Assemblies Two anchorage assemblies of each size of anchorage to be used shall be furnished, complete with distribution plates.

405.2.2 Concrete

The materials for concrete shall conform to the requirements of item 401. The concrete shall be Class D as shown in table 401-1 unless otherwise shown on the plans.

405.2.3 Reinforcement Steel

Reinforcement steel shall conform to the requirements of item 404.

405.3 CONSTRUCTION REQUIREMENTS

General

Unless otherwise ordered by the Engineer, the Contractor shall certify for the Engineer's approval that a technician skilled in the approved pre-stressing method will be available to the Contractor to give aid and instruction in the use of the pre-stressing equipment to obtain the required results.

The tensioning process shall be conducted so that the tension being supplied and the elongation may be measured at all times.

During the pre-stressing operations, standing behind or under jack will not be allowed in order to ensure that no one is injured by the flying spindle, tendon or the jack in the event of a break occurring.

405.3.1 Pre-stressing Method

The method of pre-stressing to be used shall be optional with the Contractor, provided he introduces no change in the position of centroid of the total pre-stressing force over the length of the member and in the magnitude of the final effective pre-stressing force as prescribed in the Drawings. The pre-stressing system chosen by the Contractor shall have been indicated in the tender. This option shall be subject to all requirements hereinafter specified.

Independently from the pre-stressing system to be applied, the following points have to be ensured.

(i) The safety of the anchorage of the pre-stressing tendons and their suitability for the transmission of forces to the concrete under all loads whatsoever.

(ii) That the actual losses due to friction coincide with the calculated ones for the pre-stressing.

(iii) The suitability of the proposed steel for the chosen pre-stressing system.

(iv) The length of transmission of the force to the concrete and the minimum strength of the latter necessary for pre-stressing in systems, where the pre-stressing elements are fully or partially anchored to the concrete through bond and friction.

(v) The suitability of measures taken to protect pre-stressing tendons from corrosion until the final tensioning is carried out.

The Contractor shall submit well in advance to the Engineer for approval complete details of the methods, materials, and equipment he proposes to use in the pre-stressing operations. Such detail shall outline the method and sequence of stressing, complete specifications and details of the pre-stressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures, and all other data pertaining to the pre-stressing operation, including the proposed arrangement of the pre-stressing units in the members.

An agreement certificate for the pre-stressing system shall be submitted and approved by the Engineer before any structural member to be pre-stressed may be tensioned; this agreement certificate must be issued by an authorised testing laboratory otherwise the Engineer may order such an agreement certificate from a laboratory of his choice at the cost of the Contractor. All rules referring to this agreement certificate here in after are subject to the approval of the Engineer.

405.3.2 Pre-stressing Equipment

Hydraulic jacks shall be equipped with accurate pressure gauges. The contractor may elect to substitute screw jacks or other types for hydraulic jacks. In that case, proving rings or other approved devices shall be used in connection with the jacks. All devices, whether hydraulic jack gauges or other wise, shall be calibrated so as to permit the stress in the pre-stressing steel to be computed at all times. A certified calibration curve shall accompany each device. Safety measures shall be taken by the contractor to prevent accidents due to possible breaking of the pre-stressing steel or the slipping of the grips during the pre-stressing process. All equipments shall be thoroughly washed with clean water at least once every three (3) hours during the grouting operations and at the end of use for each day.

405.3.3 Enclosures

Enclosures for pre-stressing steel shall be accurately placed at locations shown on the plans or approved by the Engineer.

All enclosures shall be of ferrous metallic material and shall be completely mortar-tight with the exception that the contractor, at his option, with the approval of the Engineer, may form the enclosures by means of cores or ducts composed of rubber or other suitable material which can be removed prior to installing the pre-stressing reinforcement. Enclosures shall be strong enough to maintain their shape under such forces as will be imposed upon them. They shall be six (6) mm. larger in internal diameter than the bar, cable, strand or group of wires, which they enclose. Where pressure grouting in specified, cores or ducts shall be provided with the pipes or other suitable connection for the injection of grout after the pre-stressing operations have been completed.

405.3.4 Handling and Placing of Steel

All steel units shall be stored and handled in such a way so as to protect them from adverse weather effects and injury.

All steel units shall be accurately placed in the position shown on the Drawings or required by the Engineer and firmly held during the placing and setting of the concrete.

Distance from the forms shall be maintained by stays, blocks, ties, or hangers approved by the Engineer. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Layers of units shall be separated by mortar blocks or other equally suitable devices. Wooden blocks shall not be left in the concrete.

Suitable horizontal and vertical spacers shall be provided, if required, to hold the wires in place in true position in the enclosure.

Epoxy coated pre-stressing steel:

Additional requirements for epoxy coated pre-stressing steel shall be as follows:

All strapping bands shall be padded or suitable banding shall be used to prevent damage to the coating. All reels of coated strand shall be handled in such a manner as not to damage the coating on the strand.

Coating damage due to handling shall be repaired in accordance with the recommendation of the manufacturer of patching material. The repaired coating shall conform to the requirements of Section 405.2.1 of this specification.

405.3.5 Placing Concrete

Concrete shall be controlled, mixed, and handled as specified in other articles of this section unless otherwise specified herein.

Concrete shall not be poured in the forms until the Engineer has inspected the placing of the reinforcement, conduits, anchorages, and pre-stressing steel and has given his approval thereof.

The concrete shall be vibrated internally or externally, or both, as ordered by the Engineer. The vibrating shall be done with care in such a manner as to avoid displacement of reinforcement, conduits, or wires.

405.3.6 Pre-tensioning

The pre-tensioning elements shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongation produced thereby. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units, if necessary, to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor end anchorages released, until the concrete has attained a compressive strength, as shown by cylinder tests, of at least two hundreds and eighty (280) kg/sq.cm and as approved by the Engineer. The elements shall be cut or released in such an order that lateral eccentricity of pre-stress will be minimum.

405.3.7 Post-Tensioning

Tensioning shall be carried out only in the presence of the Engineer or his representative unless permission has been obtained to contrary. Immediately before tensioning, the contractor shall prove that all tendons are free to move between jacking points and that members are free to accommodate the horizontal and vertical movements due to the applications of pre-stress.

Tensioning of pre-stressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions, indicate that the concrete of the particular member to be pre-stressed has attained a compressive strength of at least 280 Kg/sq.cm.

After the concrete has attained the required strength, the pre-stressing reinforcement shall be stressed by means of jacks to the required tension and stress transferred to the end anchorage(s). Stressing shall be from both ends unless otherwise required in the Contract or agreed by the Engineer. The tensioning process shall be so conducted that the tension being applied and the elongation of the pre-stressing elements may be measured at all times.

The value of the strand shortening, generally referred to as anchor set, ΔL, varies from about 3mm to 9.5mm. It depends on the anchorage hardware and jacking equipment and shall be accounted for during stressing operation.

The friction loss, ΔF_{PF}, in the elements shall be determined by the formula:

$$\Delta F_{PF} = F_{PJ}\left(1 - e^{-(Kx+\mu\alpha)}\right)$$

Where

F_{PJ} = Stress in the pre-stressing tendon at jacking

e = Base of natural logarithm

x = Length of a pre-stressing tendon from the jacking end to any point under consideration, ft

K = Wobble friction coefficient, typically about 6.6×10^{-4}/m for rigid and semirigid galvanized metal ducts [LRFD Table 5.9.5.2.2b-1]

□ = Coefficient of friction due to local deviations from tendon path, typically about 0.2/rad for rigid and semi-rigid galvanized metal sheathing and polyethylene ducts [LRFD Table 5.9.5.2.2b-1]

□ = Sum of the absolute values of angular change of post-tensioning tendon from jacking end, or from the nearest jacking end if tensioning is done equally at both ends, to the point under investigation, rad

The values of K and provided by the specialized Post Tensioning contractor, as per system adopted at site, are to be used.

Any surplus length of tendon shall be cut off by an approved method which will not affect the strength of the stressed tendon, with particular care if the use of spark erosion or oxyacetylene burning methods of cutting are approved by the Engineer.

A record shall be kept of gauge pressures and elongation at all times and submitted to the Engineer for his approval within twenty four (24) hours of each tensioning operation. The tendons shall be maintained in such a condition that they can be re-stressed until the Engineer has given final approval after inspecting the tensioning log.

405.3.8 Grouting of Bonded Steel

Post-tensioned pre-stressed bridge members preferably shall be of the bonded type in which the tensioned steel is installed in holes or flexible metal ducts cast in the concrete and bonded to the surrounding concrete by filling the tubes or ducts with grout. The grout shall be a mixture of cement and fine sand (passing a No.30 sieve) in the approximate proportion of one part cement to 0.75 part sand, the exact proportions to be adjusted to form a grout having the proper consistency and under no circumstances, shall the water cement ratio exceed 0.45. The compressive strength of the hardened grout shall not be less than one hundred and seventy (170) Kg/sq.cm after seven (7) days at a temperature of eighteen (18) degree C, when making preliminary trials for quality. The grout shall be mixed for a minimum of two (2) minutes and until a uniform consistency is obtained.

All pre-stressing reinforcement to be bonded shall be free of dirt, loose rust, grease, or other deleterious substances. Before grouting, the ducts shall be free of water, dirt or any other foreign substance. The ducts shall be blown out with compressed air until no water comes through the duct. For long members with draped strands an open tap at the low point of the duct may be necessary.

The grout shall be fluid (consistency of thick paint) but proportioned so that free water will not separate out of the mix. Unpolished aluminum powder may be added in an amount per sack of cement as approved by the Engineer. Commercial plasticisers used in accordance with the manufacturer's recommendation may be used provided they contain no ingredients that are corrosive to steel. Sufficient pressure shall be used in grouting to force the grout completely through the duct, care being taken that rupturing of the ducts does not occur.

405.3.9 Handling

Precast pre-stressed concrete members shall be transported in an upright position and the points of support with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position. In the event that the Contractor deems it expedient to transport or store precast girders in other than this position it should be done at his own risk.

Care shall be taken during storage, hoisting, and handling of the pre-casting units to prevent cracking or damage. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense.

Pre-stressed structural members shall be constructed in conformity with the drawings governing the particular type of structure to be built or as required by the Engineer.

405.3.10 Manufacture of Pre-stressed Members off the Site

i) The details of the method of manufacture shall be approved by the Engineer before work is started. When the method has been approved, no changes shall be made without the consent of the Engineer.

ii) The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and the dates when tensioning of tendons, casting of members and transfer of stress will be undertaken for the first time for each type of beam.

iii) The Contractor shall send to the Engineer not more than seven (7) days after the transfer of stress, a certificate showing the force and strain in the tendons immediately after they were anchored, the strength and age of the test cubes cast in accordance with specified procedure and the minimum age in hours of the concrete at the time the stress was applied to the member. A copy of all twenty eight (28) days cube test results relating to the work shall be sent to the Engineer as these become available. Records shall be kept so that the identity of those who stress the tendons, cast the concrete and transfer the stress on any member or line of members can be traced.

iv) Where the Engineer's Representative requires tests to be carried out, no beams to which the test relate shall be dispatched to the site until the tests have been satisfactorily completed.

405.3.11 Composite Slab Bridges

a) The manufacturing tolerances for the precast members shall no-where exceed those given for the length, cross-section and straightness in BS Code of Practice CP116(1969). The structural use of precast concrete. In addition, where beams are laid side by side in a deck:

(i) The difference in soffit level between adjacent units before the in situ concrete is placed shall no-where exceed five (5) mm for units up to five (5) meters nor ten (10) mm for longer units.

(ii) The width of the deck soffit shall be within plus twenty five (+25) mm of that described in the Contract.

(iii) In adjacent spans, the continuity of line of the outside beams shall be maintained.

(iv) The width of the gap between individual beams shall not exceed twice the nominal gap described in the contract.

(v) The alignment of transverse holes shall permit the reinforcement or pre-stressing tendons to be placed without distortion.

b) The in-situ concrete shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of deck or between longitudinal construction joints is approximately parallel to the deck supports.

c) Beams shall be prevented from moving laterally during the placing of the in-situ concrete.

405.3.12 Sampling and Testing

a) Testing of Pretensioned Beams

(i) Any beam required by the Engineer to be subjected to a load test will be selected after transfer and wherever possible before the beam has been removed from the casting yard to the storage area. The Contractor shall not proceed with a load test until he has obtained the approval of the Engineer to the detailed arrangements. Except where otherwise agreed by the

Engineer, the load test shall be carried out not less than twenty eight (28) days after casting. The cost of the load test shall be born by the Contractor.

(ii) The beam shall be supported at its design points of bearing. The specified test loads shall be applied equally at the third points of the span in not less than ten (10) approximately equal stages. The maximum load shall be sustained for five (5) minutes and then removed in not less than five (5) approximately equal stages. The mid-span deflection relative to a straight reference line joining the points of support shall be measured for each value of the load and five (5) minutes after removal of the load.

(iii) Loads shall be measured with an accuracy of $\pm$ two (2) per cent or 50kg and deflections with an accuracy of $\pm$ decimal five (0.5) millimeter.

(iv) The load-deflection graph shall be plotted from these values and shall show no appreciable variation from a straight line. If after five (5) minutes of removal of the load the beam does not show a recovery of at least ninety (90) per cent of the maximum deflection recorded during the test, the test loading shall be repeated. The beam shall be considered to have failed the test if the recovery five (5) minutes after removal of the test load for the second time is not at least ninety (90) per cent of the maximum deflection recorded during the second test.

(v) The result of the test shall be deemed to apply to the other beams cast in the same production line but in the event of failure any additional beam may be separately tested at the contractor's option.

(vi) The contractor shall supply to the Engineer record sheets of the test showing the age of the beam at the time of the test, loads, deflections, load-deflection curves and calculated value of Young's Modules of Elasticity (E).

(vii) In addition, the record sheets supplied by the contractor to the Engineer shall show the temperatures of the top and bottom surfaces of the beam measured at the time of the test.

b) Testing of Pre-stressing Anchorages

Anchorages for post-tensioning shall be tested in accordance with the procedure described in BS4447 or as approved by the Engineer. For each anchorage system used in the Works, the characteristic value for anchorage efficiency shall be not less than ninety (90) percent.

405.3.13 Curing Concrete

a) General

For all pre-stressed concrete operations the curing procedures shall be well established and properly controlled. Curing shall be commenced immediately following initial set or completion of surface finishing. Members shall be kept wet during the entire period of curing.

b) Method of Curing

The curing methods shall conform to those detailed under item 401.3.8.

405.4 MEASUREMENT AND PAYMENT

405.4.1 Measurement

Measurement and payments for the various items in pre-stress concrete work shall be made in accordance with appropriate items of relevant sections, as depicted in the drawings.

405.4.2 Payment

405.4.2.1 Precast Pre-stressed Concrete Member

The quantity to be paid for shall be the number of pre-stressed concrete structural members of the several types and sizes, constructed and installed in place, as per drawings completed and accepted. Each member shall include the concrete, reinforcement and prestressing steel, enclosures for prestressing steel, anchorage, plates, nuts, formwork, shuttering and centering if required, and other such material contained within or attached to the unit.

405.4.2.2 Cast-in-Place Prestressed Concrete

The work to be paid for under this item will be only the prestressing work as specified here and shown on the Drawings or required by the Engineer and shall include supply and installation of prestressing steel, spacers, enclosures, anchorages plates, nuts and other such material deemed necessary to complete the work. Steel reinforcement, concrete, falsework, and formwork will, unless otherwise prescribed, be measured and paid for according to item No. 401and 404 respectively.

Pay item No. Description and Unit of Measurement for Precast Prestressed Concrete Members and Cast-in-Place Prestressed Concrete will be covered, under specified BOQ item number provided in special provisions, as per drawings and other related documents for following item separately.

Pay Item No.	Description	Unit of Measurement
405 a	Providing and Stressing 3/8" to ½" dia. high tensile steel Wire/ Rope strands including cost of corrugated steel Sheath duct, Anchorage cone sets, Male & female cones, block for cones, plugs for bolts for cables, air lock, , Steel tube, Grouting and Supply of recorded data in triplicate complete in all respect as per Specifications or as directed by the Engineer	SM
405b	Launching of Girder	TON

SECTION 406 JOINTS AND BEARING DEVICES FOR CONCRETE STRUCTURES

406.1 DESCRIPTION

The work covered in this item shall consist of furnishing all plant, equipment, materials and labour in performing all operations in connection with furnishing and placing (in concrete structures) all deck expansion joints and seals, metal bearing devices and elastomeric bearing pads complete and in accordance with the specifications, the Drawings, and or as required by the Engineer.

406.2 MATERIAL REQUIREMENTS

406.2.1 Concrete Joint Fillers and Seals

a. Preformed Non-Extruding Resilient Bituminous Expansion Joint Filler

Unless otherwise directed by the Engineer Preformed Non-Extruding Resilient Bituminous Expansion joints filler shall conform to the requirements of AASHTO M-213.

b. Neoprene Rubber Sheet with Bitumastic Joint Seal

Unless otherwise directed by the Engineer, neoprene rubber sheets shall be minimum six (6) mm in thickness, meeting the requirements of Item 406.2.3, shall be used as joint filler covered with a bitumastic seal as shown in the Drawings. The seal shall ensure prevention of moisture and debris from penetrating into the joint.

c. Polyvinyl Chloride (PVC) Water Stop

Polyvinylchloride water stop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinylchloride (PVC). The compound shall contain such additional resins, plasticizers, stabilizers or other materials needed to ensure that when the material is compounded and extruded to the shapes and dimensions shown. PVC Water Stop shall comply with US Army Corps of Engineers Standard CRD-C-572-74 having following properties:

Table 406-1: Properties of PVC Water Stop

Physical Characteristic	Requirement	Test Method
Tensile strength using die c, min.	1750 psi	573
Ultimate elongation using die c, min.	300%	573
Low temperature brittleness, no sign of failure such as cracking or chipping at	- 35 deg F (-37.2 deg C)	570
Stiffness in flexure, not less than	600 psi	571

d. Asphalt Felt

Asphalt Felts for waterproofing shall comply with ASTM D-226 (Type-II) or ASTM D-227 as specified in the drawings. Asphalt used in felts shall conform to the requirements of ASTM D-449 in the construction of waterproofing systems. If thickness of Asphalt Felt is not mentioned on Drawings, minimum thickness to be used shall be three (3) mm or as directed by the Engineer.

406.2.2 Steel for Deck Expansion Joints

Plates, angles or other structural shapes including anchor bolts required for the expansion joint seals shall conform, unless otherwise directed by the Engineer, to the requirements of AASHTO M-160 (ASTM A-6) for Structural Steel and shall be hot dipped in zinc (galvanized) with the exception of the bolts, nuts and washers which shall be of stainless steel conforming to ASTM F-593 and ASTM F-594.

High strength bolts shall comply with ASTM A-325 or ASTM A-490.

406.2.3 Elastomer for Deck Expansion Joint Seals

Elastomer shall be durable vulcanized neoprene or natural rubber reinforced with steel laminates. Neoprene conforming to AASHTO M-297 shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall have the following physical characteristics. Preparation of sample shall be carried out in accordance with ASTM Method D-3182 & D-3183.

Table 406-2: Physical Characteristics of Neoprene

Test Description	Test Designation	Requirements
Hardness, Durometer A	ASTM D-2240	55 $\pm$ 5 points
Tensile Strength	ASTM D-412	140 Kg/sq cm min.
Elongation at Break	ASTM D-412	250 percent min.
Low Temperature recovery, 72h at -14 deg. C, 50% Deflection	AASHTO M-297	88 percent min.
Low Temperature recovery, 22h at -29 deg. C, 50% Deflection	AASHTO M-297	83 percent min.
High Temperature recovery, 70h at 100 deg.C, 50% Deflection	AASHTO M-297	85 percent min.
Ozone Resistance, 20% Strain, Exposure to 300 PPHM Ozone for 70 hours at 40 deg. C.	ASTM D-1149	No cracks
Oil Swell – Weight Change, After soaking in ASTM Oil No. 3 for 70 hours at 100 deg. C.	ASTM D-471	45 percent max.

406.2.4 Modular Bridge Joint System (MBJS)

Modular Bridge Joint System shall consist of two or more elastomeric seals held in place by edge beams that are anchored to structural elements (deck, abutments etc.) and one or more transverse center beams that are parallel to the edge beams. Material for MBJS shall comply with Items 406.2.2 and 406.2.3 of this specification. Aluminum components in the modular joint shall be of Aluminum Alloy Peraluman 460 (Aluminum 5083).

Stainless steel sheets for the sliding surfaces of the support bars shall conform to the requirements of ASTM A-240 type 302 or 304. Support bars shall incorporate stainless steel sliding surfaces to permit joint movement.

If elastomeric compression sealing element is used, it shall meet the requirements of AASHTO M-220. Lubricant/Adhesive for installing the preformed elastomeric elements in place shall be a one-part, moisture-curing, polyurethane and hydrocarbon solvent mixture as recommended by the manufacturer and containing not less than 65 percent solids.

Support bar bearings shall be fabricated from elastomeric pads with poly tetra Fluor ethylene (PTFE) surfacing or from polyurethane compound with PTFE sliding surfaces. PTFE shall conform to Item 406.2.5 (b) of this specification.

Suitable elastomeric type springs which work longitudinally shall be used to maintain the equidistant spacing between transverse edge and separation beams when measured at any given cross section through the joint.

The expansion joint device shall effectively seal the joint opening in the deck surface and barrier curbs against the entrance of water and foreign materials. There shall be

no appreciable change in the deck surface plane with the expansion and contraction movements of the bridge.

The device shall consist of a shop-fabricated modular assembly of transverse neoprene seals, edge and separation beams, bearing on support bars spanning the joint opening. The assembly shall maintain equal distances between intermediate support rails, at any cross section, for the entire length of the joint. The assembly shall be stable under all conditions of expansion and contraction, using a system of longitudinal control springs and upper and lower support beam bearings and springs.

MBJS shall permit movements in all six degrees of freedom i.e. translation along all three directions and rotations about all three axes. The minimum movement range capabilities of MBJS shall be as shown on the drawings.

MBJS shall be shipped to job site fully assembled. No intermediate field splices shall be allowed for joints up to a length of eighteen (18) meters.

Joints exposed to traffic shall have skid resistant surface treatment, and all parts shall be resistant to attrition and vehicular impact throughout the service life.

406.2.5 Metal Bearing Devices

Metal Bearing devices shall be able to transmit loads while facilitating translation and / or rotation as specified. Unless otherwise directed by the Engineer or provided in the Special Provisions, the requirements for metal bearings and their components shall conform to AASHTO LRFD Bridge Design Specifications (4th Edition-2007) as follows:

a. Metal Rocker or Roller Bearing

Rocker and Roller Bearings shall be made of stainless steel conforming to ASTM A-240 or of Structural Steel conforming to AASHTO M-169, M-102 or M-270, Grades 250, 345, 345W. If Bronze or Copper sliding surfaces are used, they shall conform to Item 406.2.5 (e).

Each individual curved contact surface shall have constant radius. Bearing with more than one curved surface shall be symmetrical about a line joining the centers of their two curved surfaces. Bearing shall be stable and their geometry shall be such as to permit free movement of the bearings.

b. Poly tetra Fluor ethylene (PTFE) Surface and Mating Surface

PTFE may be used in sliding surfaces of the bridge bearings to accommodate translation or rotation. PTFE surface shall be made from pure virgin PTFE resin satisfying requirements of ASTM D-4894 or D-4895. It shall be fabricated as unfilled sheet, filled sheet or fabric woven from PTFE and other fibers.

Unfilled sheets shall be made from PTFE resign alone. Filled sheets shall be made from PTFE resin uniformly blended with glass fibers, carbon fibers or other chemically inert filler. The filler content shall not exceed 15 percent of glass fibers and 25 percent of carbon fibers. Woven fiber PTFE shall be made from pure PTFE fibers. Reinforced woven fiber PTFE shall be made by interweaving high strength fibers, such as glass, with the PTFE in such a way that reinforced fibers do not appear on the sliding face of the finished fabric.

Lubricant to be used for PTFE surface shall be Silicone grease and shall comply with US Military Specifications MIL-S-8660.

For all applications, the thickness of PTFE shall be at least 1.5mm after compression. Recessed sheet PTFE shall be of following thickness:

Table 406-3: Thickness of the Recessed Sheet PTFE

Maximum Dimension of PTFE (mm)	Min. Thickness of PTFE (mm)
Up to 600	4.50
Greater than 600	6.00

Woven fabric PTFE shall have minimum thickness of 1.5mm and maximum thickness of 3.0mm over the highest point of metallic substrate to which it is mechanically interlocked.

PTFE shall be used in conjunction with mating surface. Mating surface shall be stainless steel type 304, conforming to ASTM A-167 or ASTM A-264 and shall have a surface finish of 0.20□m RMS or better. Finishes on curved metallic surfaces shall not exceed 0.40□m RMS. The mating surface shall be large enough to cover the PTFE at all times.

Thickness of stainless steel mating surface shall be as follows:

Table 406-4: Thickness of the Stainless Steel Mating Surface

Maximum Dim. of Mating Surface (mm)	Min. Thickness of Mating Surface (mm)
Up to 300	1.50
Greater than 300	3.00

If PTFE is to be bonded to an elastomeric layer, the elastomeric layer shall have Shore-A Durometer hardness of at least Ninety (90).

Certification testing from production lot of PTFE shall be carried out as instructed by the Engineer to ensure that the friction actually achieved in bearing satisfies the design requirements.

c. Bearings with Curved Sliding Surfaces

Bearings with curved (spherical or cylindrical) surfaces shall consist of two metal parts with matching curved surfaces and low friction sliding interface. The two surfaces of sliding interface shall have equal nominal radii. The material used shall satisfy the requirements of Items 406.2.5 (b) and (e)

d. Pot Bearing Devices

Pot bearing device shall consist of a pot, a piston, an elastomeric disc and sealing rings.

The elastomeric disc shall be made from a compound based on virgin neoprene conforming to Item 406.2.3. Top and bottom surfaces of Elastomer shall be treated with Silicone grease to facilitate rotation.

The pot and piston shall be made from structural steel conforming to AASHTO M-270 Grades 250, 345, 345W or from stainless steel conforming to ASTM A-240. The finish of surfaces in contact with elastomeric pad shall be smoother than 1.5□m. Piston will have the same plan shape as inside of the pot. Yield strength and hardness of piston shall not exceed that of the pot.

Brass sealing rings shall conform to ASTM B-36 (half hard alloy 260) for rings of rectangular cross-section and ASTM B-16 (half hard alloy 360) for rings of circular cross-section.

e. Bronze or Copper Alloy Sliding Surfaces

Bronze or Copper alloy sliding surfaces shall be used in Metal Bearing Devices where specified and shall be of the following types:

- Flat sliding surfaces to accommodate translational movements
- Curved sliding surfaces to accommodate translation and limited rotation
- Pins or cylinders for shaft bushing of rocker bearings with large rotations

Bronze sliding surfaces shall conform to AASHTO M-107 (ASTM B-22) and shall be made of alloy C90500, C91100 or C86300 or as specified. The mating surface shall be structural steel with Brinell hardness value of at least 100 points greater than that of Bronze. Mating surface shall be machined to match the geometry of Bronze surface to provide uniform bearing and contact.

Bronze bearing shall be of lubricated type and shall have following characteristics:

- The bearing surfaces shall have lubricant recesses consisting of either concentric rings, with or without central circular recesses with a depth at least equal to the width of the rings or recesses.
- The recesses or rings shall be arranged in a geometric pattern so that adjacent rows overlap in the direction of motion.
- The entire area of all bearing surfaces that have provision for relative motion shall be lubricated by means of the lubricant-filled recesses.
- The lubricant-filled areas shall comprise not less than 25 percent of the total bearing surfaces.
- The lubricating compound shall be integrally molded at high pressure and compressed into the rings or recesses and project not less than 0.25 mm above the surrounding bronze plate.

f. Disc Bearings

Disc Bearings shall accommodate rotation by deformation of a single elastomeric disc. It shall be moveable, guided, unguided or fixed type, as specified in the drawings. Movement shall be accommodated by sliding polished stainless steel on PTFE.

Metal component of the bearing shall be made from structural steel conforming to AASHTO M-270 Grade 250, 345 or 345W or from stainless steel conforming to ASTM A-240.

Elastomeric disc shall be made from a compound based on polyether Urethane using virgin materials. The hardness shall be between 45 and 65 on Shore-D scale.

g. Guides and Restraints

For steel bearings, guides and restraints shall be made from steel conforming to AASHTO M-270 Grades 250, 345, 345W or stainless steel conforming to ASTM A-240. Guides and restraints shall have low friction material at their sliding contact surfaces, approved by the Engineer.

h. Other Bearing Systems

Bearing systems made from components not specified in this specification may also be used if specified in Special Provisions, subject to the approval of the Engineer. Contractor shall furnish all necessary tests in this regard to the satisfaction of the Engineer.

406.2.6 Elastomeric Bearing Pads

General

Elastomeric bearings as herein specified shall include plain bearings (consisting of elastomer only) and laminated bearings (consisting of layers of elastomer restrained at their interfaces by bonded laminates). Elastomeric bearing pads shall comply with AASHTO M-251

The reinforcing steel plate laminations for bearing pads shall conform to the requirements of ASTM A-36 or ASTM A-570.

Elastomeric bearing pads shall conform to the requirements in these specifications and the Special Provisions.

The elastomer for the manufacture of the bearing is furnished in four grades of low-temperature properties. The grades and typical operating temperature conditions for each grade are as follows:

Grade 0	Suitable for continuous use down to + 5°C.
Grade 2	Sub-zero temperatures occur at night and occasionally persist for no more than 1 or 2 days.
Grade 3	Same as 2 but occasional periods of up to 2 weeks continuously below zero.
Grade 5	Sub-zero temperatures down to – 40°C persisting for several months each year with up to 2 months continuously below – 15°C.

If a grade is not specified Grade 2 shall be furnished. An elastomer of a higher grade number may be substituted for any lower grade.

Pads twelve (12) mm and less in thickness may be either laminated or all elastomer.

Pads over twelve (12) mm in thickness shall be laminated.

Laminated pads shall consist of alternate laminations of elastomer and metal or elastomer and fabric bonded together.

The thickness called for an elastomeric bearing pad is deemed to be the total effective thickness of the elastomeric laminations.

The outside laminations shall be metal or fabric. The outside edges of metal laminations shall be coated over with elastomer not more than three (3) mm in thickness.

The edges of the steel reinforcing plates of the bearing pads shall be carefully treated to prevent notch effects. Steel plates shall be fully enclosed in elastomer so that there is no danger of corrosion.

Laminations of elastomer shall be 12 mm $\pm$ 3 mm thickness. Variation in thickness of an individual elastomer lamination shall not exceed three (3) mm within the width or length of a pad and the variation in thickness of all elastomer laminations within a pad shall be such that each metal or fabric lamination will not vary by more than three (3) mm from a plane parallel to the top or bottom surface of the pad.

The total overall thickness of a pad shall not be less than the thickness shown on the plan nor more than six (6) mm greater than that thickness. Variation of total thickness within an individual pad shall not exceed three (3) mm.

The length and width of a pad shall not vary more than three (3) mm from the dimensions shown on the Drawings.

Where elastomeric bearing pads over twelve (12) mm, in thickness are shown on the Drawings or required by the Engineers, such pads may be manufactured as a molded laminated pad, or at the option of the Contractor, may be made up by stacking individual laminated pads.

When laminated pads are stacked, their contact surfaces shall be cleaned prior to stacking and an approved method shall be used to hold the individual pads in the stack in proper alignment. Pads of all elastomer or with fabric laminations may be cut from large sheets. Cutting shall be performed in such a manner as to avoid heating of the material and to produce a smooth edge with no tears or other jagged areas and to cause as little damage to the material as possible.

Corners and edges of molded pads may be rounded at the option of the Contractor. Radius at corners shall not exceed ten (10) mm and radius of edges shall not exceed three (3) mm.

The bond between elastomer and metal or fabric shall be such that, when a sample is tested for separation, failure shall occur within the elastomer and not between the elastomer and metal or fabric.
Metal laminations shall be rolled mild steel sheets not less than twenty (20) gauge in thickness.

Fabric laminations shall be either, (1) a long chain synthetic polymer containing at least eighty five (85) percent of polyester from ethylene glycol and teraphthalic acid or (2) a long chain synthetic polymeric amid from hexamethylenediamine and adipic acid. Each ply of fabric shall have a breaking strength of not less than 125 Kg. per cm. of width in both directions. Fabric laminations shall be single ply at top and bottom surfaces of the pad and either double ply or double strength within the pad.

The sole polymer in the elastomeric compound shall be neoprene and shall be not less than sixty (60) percent by volume of the total compound.

Sampling shall be performed in accordance with AASHTO M-251 as appropriate for the tests required during or immediately after manufacture.

The elastomer, as determined from test specimens, shall conform to the following:

Table 406-5: Required Properties of Elastomer

Test	ASTM Designation	Requirements
Tensile strength, Kg / sq. cm	D 412	160 Min.
Elongation at break, percent	D 412	350 Min.
Compression set, 22 hrs. at 100°C, percent	D 395 (Method B)	35 Max.
Tear Strength, Kg / sq. cm	D 624 (Die C)	13 Min.
Hardness, Durometer (Shore A)	D 2240	60 $\pm$ 5
Ozone resistance (concentration 100$\pm$20 PPHM) @ 20% strain, for 100 hrs. at 37.7°C $\pm$ 1°C	D 1149	No Cracks
Low temperature brittleness	D 746	Passed
Shear Modulus at 23°C $\pm$ 1°C, Kg / sq. cm	D 4014	9.18 – 14.28

After accelerated aging in accordance with ASTM Designation D 573 for 70 hours at 100 degree C, the elastomer shall not show deterioration changes in excess of the following:

Tensile strength, percent	(-) 15
Elongation at Break, percent	(-) 40
Hardness, points	+ 15
Shear Test (without vertical load)	7 Kg/sq.cm (Min)

The Contractor shall furnish to the Engineer a certification by the manufacturer that the elastomer, and fabric (if used), in the elastomeric bearing pads to be furnished conforms to all of the above requirements. The certification shall be supported by a certified copy of the results of tests performed by the manufacturer upon samples of the elastomer and fabric to be used in the pads.

The Engineer will take a sample of not less than 15 x 30 cm in size for testing from each lot of pads or batch of elastomer to be furnished, whichever results in the greater number of samples. The samples will be selected at random at the point of manufacture or, at the option of the Contractor at the job site. Samples taken at the job site shall consist of complete pads as detailed on the plans, and the Contractor shall furnish additional complete pads to replace those taken for testing. Pads shall be available for sampling three (3) weeks in advance of intended use. All sample pads for testing shall be furnished by the Contractor at his expense.

The Bearing Pads shall meet the following requirements:

Table 406-6: Required Properties of Bearing Pad

Test Description	Test Designation	Requirements
Compressive strain at max. design compressive load	AASHTO M-251	0.10 Max.
Compressive load at 1.5 times max. design compressive load	AASHTO M-251	Passes all requirements
Bond Strength (for laminated bearing)	ASTM D-429 (Method B)	6.9 KN/m Min.

406.3 CONSTRUCTION REQUIREMENTS

406.3.1 Open Joints

Open joints shall be constructed at the locations shown on the Drawings or required by the Engineer using a suitable material, which is subsequently removed. When removing the material, care shall be exercised to avoid chipping or breaking of concrete. Reinforcement shall not extend across an open joint, unless shown on the Drawings.

406.3.2 Filled Joints

When joints of preformed type are required on the Drawings or by the Engineer, the filler shall be placed in correct position before concrete is being placed against the filler. Preformed Filler with holes and cracks shall not be permitted and shall be rejected.

406.3.3 Steel Joints

Plates, angles or other structural shapes shall be accurately shaped at the shop, to conform to the section of the concrete floor as per drawings. The fabrication shall conform to the requirements in Special Provisions. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Methods approved by the Engineer shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that to avoid impairment of the clearance in any manner.

406.3.4 Water Stops (Joint Seals)

Water-stops shall be furnished and installed in accordance with the details shown on the Drawings or where required by the Engineer and in accordance with the provisions in these specifications.

Water-stops shall be furnished in full length for each straight portion of the joint, without field splices. Manufacturer's shop splices shall be fully vulcanized.

Reinforcing bars provided to support the water-stops shown on the Drawings or as required by the Engineer shall be securely held in position by the use of spacers, supporting wires, or other approved devices. Such reinforcing bars shall be considered, for payment purposes, as a part of the water-stop. If, after placing concrete, water-stops are materially out of position or shape, the surrounding concrete shall be removed, the water-stop reset, and the concrete replaced, all at the Contractor's expense.

Field splices for neoprene water-stops shall be either vulcanized, or mechanical, using stainless steel parts, or made with a splicing union of the same stock as the water-stop, at the option of the Contractor. All finished splices shall have a full size tensile strength of eighteen (18) kg per cm of width.

Field splices for polyvinyl chloride water-stops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not char the plastic.

Water-stops when being installed shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

406.3.5 Modular Bridge Joint System (MBJS)

The manufacturer of the expansion device shall provide a qualified technical service representative to supervise installation. Modular expansion joint devices shall be factory prefabricated assemblies, preset by the manufacturer prior to shipment with provisions for field adjustment for the ambient temperature at the time of installation.

Unless otherwise shown on the plans, the neoprene seals shall be continuous without any field splices. All steel surfaces of the prefabricated assembly shall be shop painted with the primer specified for structural steel, except areas in direct contact with the seals, galvanized items and stainless steel surfaces.

The metal surfaces in direct contact with the neoprene seals shall be blast cleaned to permit a high strength bond of the lubricant/adhesive between the neoprene seal and mating metal surfaces.

The prefabricated joint assembly shall be properly positioned and attached to the structure according to the manufacturer’s approved shop drawings. The attachment shall be sufficiently rigid to prevent non-thermal rotation, distortion, or misalignment of the joint system relative to the deck prior to casting the concrete. The joints shall be adjusted to the proper opening based on the ambient temperature at the time of

installation and then all restraints preventing thermal movement shall be immediately released and/or removed. The joint assembly units shall be straight, parallel and in proper vertical alignment or reworked until proper adjustment is obtained prior to casting of the concrete around the joint.

After the joint system is installed, the joint area shall be flooded with water and inspected, from below for leakage. If leakage is observed, the joint system shall be repaired, at the expense of the Contractor, as recommended by the manufacturer and approved by the Engineer.

406.3.6 Metal Bearing Devices

Steel bearing plates, bars, rockers, assemblies, and other expansion or fixed devices shall be installed in accordance with the details shown on the plans and as per manufactures' recommendations. All exposed steel parts of bearings not made from stainless steel shall be protected against corrosion by hot-dip galvanized or an approved paint system.

The bearing plates shall be set level and the rockers or other expansion devices shall be set to conform to the temperature at the time of erection or to the setting specified.

When bearing assemblies or masonry plates are shown on the Drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding or other approved means to a true level plane which shall not vary perceptibly from a straight edge placed in any direction across the area. The finished plane shall not vary more than three (3) mm from the elevation shown on the Drawings or that required by the Engineer.

406.3.7 Elastomeric Bearing Pads

When elastomeric bearing pads are shown on the Drawings, the concrete surfaces on which pads or packing are to be placed shall be wood float finished to a level plane which shall not vary more than one and a half (1.5) mm from a straightedge placed in any direction across the area. The finished plane shall not vary more than three (3) mm from the elevation shown on the Drawings or that required by the Engineer.

406.4 MEASUREMENT AND PAYMENT

406.4.1 Measurement

a) Filled Concrete Joints

The quantity to be paid for shall be in square meters of either expansion joint with preformed joint filler or expansion joint with neoprene rubber sheet six (6) mm thick and covered with bitumastic seal, completed and accepted in work.

b) Steel Joints

The quantity to be paid for shall be the number of kilograms of steel for local steel joints fabricated, galvanized and placed in the work completed and accepted. Imported steel joints shall be paid in Linear Meters of completed work.

c) Water Stops

The quantity to be paid for shall be the number of linear meters of water-stop placed in the work, completed and accepted.

d) Bearing Devices

The quantity to be paid for shall be the number of bearing devices for Metal bearing or Cubic centimeter of elastomeric bearing pads installed in the work completed and accepted.

e) Asphaltic Felt

The quantity to be paid shall be in square meter of Fibre/Fabric based asphaltic felt including striking coat/paint coat and flood coat of special industrial bitumen and sand blinding as approved by the Engineer, laid in place as directed by the Engineer.

406.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below and shown in the Bill of Quantities which price and payment shall be full compensation for furnishing all materials, labour, equipment, tools and incidentals and any work pertaining to joints and bearings and which is not paid for separately, necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
406 a	Premoulded joint filler 12mm thick with bitumastic joint seal	SM
406 b	Neoprene rubber joint filler 12mm thick with bitumastic joint seal	SM
406 c	Steel Expansion joints (Local)	KG
406 d	Expansion joint with two extruded aluminum alloy section for 50mm movement (USA/EU make)	LM
406 e	Water Stops 8" Size	LM
406 f	Elastomeric Bearing Pads(According to size and thickness) Local	CCM
406 g	Asphalt Felt (3 ply)	SM
406 h	Steel or Metal Bearing Devices	KG
406 i	Expansion joint with cast aluminum alloy triangular teeth for 110mm movement (USA/EU make)	LM
406 j	Expansion joint with cast aluminum alloy triangular teeth for 300mm movement (USA/EU make)	LM
406 k	Expansion joint monobloc type for 65mm movement (USA/EU make)as selected/approved by Engineer In-charge according to manufacturer/vendors Specifications.	LM
406 l	Elastomeric Bearing Pads(According to size and thickness)USA/EU make	CCM

SECTION 407 P I L I N G

407.1 DESCRIPTION

This work shall consist of performing all operations in connection with furnishing, driving, cutting off and load testing of piles to obtain the specified bearing value complete in place and strictly in accordance with these Specifications and as shown on the Drawings.

The Contractor shall furnish the precast piles in accordance with an itemized list, which will be provided by the Engineer, showing the number and lengths of all piles. When cast-in-place concrete piles are specified on the Drawings, the Engineer will not furnish the Contractor, an itemized list showing the number and length of piles. When test piles and load tests are required in conformance with sub-items 407.3.8 and 407.3.9 respectively, the data obtained from such test loads will be used in conjunction with other available subsoil information to determine the number and lengths of piles to be furnished. The Engineer will not prepare the itemized list of piles for any portion of the foundation area until all loading tests representative of that portion have been completed.

The contractor shall provide an outline of his proposed method for constructing large diameter pile when submitting his tender; the proposed method of boring being stated.

Not less than two weeks before the contractor proposes to commence piling, detailed proposal for the piling shall be delivered to the Engineer. These proposals shall include full details of materials, equipment and method to be used in the construction of piles.

If it is proposed to use bentonite slurry, this shall also be described.

Work on piling shall not commence until the contractor's proposals have been approved by the Engineer and communicated to the contractor.

The requirements herein are minimum. Strict compliance with these requirements will not relieve the Contractor of the responsibility for adopting whatever additional provisions may be necessary to ensure the successful completion of the work.

The kind and type of piles shall be as shown on the Drawings and/or as specified. No alternate types or kinds of piling shall be used, except with the written approval of the Engineer each time.

407.2 MATERIAL REQUIREMENTS

407.2.1 Types of Piles

a. Untreated Timber Piles

Untreated timber piles shall conform to the requirements of AASHTO M 168.

b. Treated Timber Piles

Treated timber piles shall conform to the requirements of AASHTO M 133 and M 168. Unless otherwise called for on the drawings, the timber piles shall be treated with creosote according to the Standard AWPA PI of the American Wood-Preservers Association.

c. Reinforced Concrete Cylindrical Piles

Diameter of reinforced concrete piles shall be as shown on the Drawings and may or may not have permanent lining, as shown on the drawing.

Reinforcing Steel shall conform to the requirements under Item 404 - Steel Reinforcement.

Concrete shall meet all the requirements for specified Class as provided under Item 401 and shall be of Class-D unless otherwise specified.

d. Structural Steel Piles

Structural steel piles shall be rolled steel sections of the type, weight and shape called for on the Drawings. The piles shall be structural steel conforming to the requirements of ASTM A-36, except that steel produced by the Acid-Bessemer process shall not be used.

The steel piles shall be coated with red lead paint conforming to AASHTO M-72 as instructed by the Engineer, unless otherwise specified.

e. Precast Concrete Piles

Concrete for piles shall meet all the requirements for the specified class as provided under Item 401 - Concrete. The concrete shall be of Class-D1 unless otherwise specified.

Reinforcing Steel shall conform to the requirements under Item 404 - Steel Reinforcement.

Pre-stressed concrete piles shall conform to Item 405 – Pre-stressed Concrete Structures.

Precast piles shall be made in accordance with the Drawings, and reinforcement shall be placed accurately and secured rigidly in such manner as to ensure its proper location in the completed pile. The concrete cover as measured to the outside face of ties or spirals shall not be less than five (5) cm.

The piles shall be cast separately or, if alternate piles are cast in a tier, the intermediate piles shall not be cast until four (4) days after the adjacent piles have been poured. Piles cast in tiers shall be separated by tar paper or other suitable separating materials. The concrete in each pile shall be placed continuously. The completed piles shall be free from stone pockets, porous spots, or other defects, and shall be straight and true to the form specified. The forms shall be true to line and built of metal, plywood, or dressed lumber. A two and half (2.5) cm chamfer strip shall be formed on all edges. Forms shall be watertight and shall not be removed within twenty four (24) hours after the concrete is placed. Piles shall be given a surface finish according to Item 401.3.7 - Concrete Surface Finishing.

Piles shall be cured in accordance with the requirements of Item 401.3.8 (e) - Curing Precast Concrete Piles.

Piles shall not be moved until the tests indicate a compressive strength of eighty (80) percent of the design twenty eight (28) days compressive strength and they shall not be transported or driven until the tests indicate a compressive strength equal to the design twenty eight (28) days compressive strength.

When concrete piles are lifted or moved, they shall be supported at the points shown on the Drawings or, if not so shown, as instructed by the Engineer.

407.2.2 Pile Shoes

Pile shoes when required shall be of the design as called for on the Drawings or by the Engineer.

407.2.3 Pile Splices

Materials for pile splices, when splicing is allowed, shall be of the same quality and characteristics as the materials used for the pile itself and shall follow the requirements given on the Drawings unless otherwise directed by the Engineer.

407.3 CONSTRUCTION REQUIREMENTS

407.3.1 Driven Piles

a. Location and Site Preparation

Piles shall be used where indicated on the Drawings or as directed by the Engineer.

All excavations for the foundation in which the piles are to be driven shall be completed before the driving is begun, unless otherwise specified or approved by the Engineer. After driving is completed, all loose and displaced materials shall be removed from around the piles by hand excavation, leaving clean solid surfaces to receive the concrete for foundations.

b. Determination of Pile Length

The criteria for pile length and bearing capacity will be determined by the Engineer according to the results from test piles and load tests. The piles shall be driven to such depths, that the bearing loads indicated on the Drawings are obtained.

The criterion for pile length may be one of the following:

1) Piles in sand and gravel shall be driven to a bearing value determined by use for the pile driving formula or as decided by the Engineer.

2) Piles in clay shall be driven to the depth ordered by the Engineer. However, the bearing value shall be controlled by the appropriate pile driving formula if called for by the Engineer.

3) Piles shall be driven to refusal on rock or hard layer when so ordered by the Engineer.

The contractor shall be responsible for correct pile lengths and bearing capacities according to the criteria given by the Engineer.

c. Pile Driving

All piles shall be driven accurately to the vertical or the batter as shown on the drawings. Each pile shall, after driving, be within fifteen (15) cm from the theoretical location underneath the pile cap or underneath the superstructure in the case of pile bents. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

Piles shall be used only in places where a minimum penetration of three (3) meters in firm materials, or five (5) meters in soft materials, can be obtained. Where a soft stratum overlies a hard stratum, the piles shall penetrate to hard material up to a sufficient distance to fix the ends rigidly.

All pile driving equipment is subject to the Engineer's approval. The Contractor is responsible for sufficient weight and efficiency of the hammers to drive the piles down to the required depth and bearing capacity. Hammers shall be gravity hammers, single acting steam or pneumatic hammers or diesel hammers. Gravity hammers shall not weigh less than sixty (60) percent of the combined weight of the pile and driving head

and not less than 2,000 Kg. The fall shall be adjusted so as to avoid injury to the pile and shall in no case exceed one (1) m for timber and steel piles and one half (0.5) M for concrete piles unless otherwise specified or approved by the Engineer. The plant and equipment furnished for steam hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The boiler or pressure tank shall be equipped with an accurate pressure gauge and another gauge shall be supplied at the hammer intake to determine the drop in pressure between the gauge and the hammer. When diesel hammers are used, they shall be calibrated with test piling and/or test loads in accordance with Item 407.3.9.

Water jets shall be used only when permitted in writing by the Engineer. When water jets are used, the number of jets and the nozzle volume and pressure shall be sufficient to erode the material adjacent to the pile freely. The jets shall be shut off at a depth not less than three (3) M before final tip elevation is reached, and the piles driven solely by hammer to final penetration as required by the Engineer.

Piles shall be supported in line and position with leads while being driven. Pile driving leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and shall be held in position by guys or steel braces to ensure rigid lateral support to the pile during driving. The leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit proper placing of batter piles. The driving of piles with followers shall be avoided if practicable and shall be done only under written permission from the Engineer.

The method used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete, injurious splitting and brooming of the wood, or deformation of the steel. Manipulation of piles to force them into proper position, if considered by the Engineer to be excessive, will not be permitted.

The pile tops shall be protected by driving heads, caps or cushions in accordance with the recommendations from the manufacturer of the pile hammer and to the satisfaction of the Engineer. The driving head shall be provided to maintain the axis of the pile in line with the axis of the hammer and provide a driving surface normal to the pile.

Full-length piles shall be used where practicable. Splicing of piles when permitted shall be in accordance with the provisions of Item 407.3.5. All piles shall be continuously driven unless otherwise allowed by the Engineer.

d. Pile Driving Formulae

Pile driving formulae may be used to determine the number of blows of hammer per unit of pile penetration needed to obtain the specified bearing capacity for piles driven in the sub-soils at the site. Piles shall be driven to a final resistance as indicated on the plans determined by the formula proposed in special specifications or the following formula if no formula is proposed:

For drop hammer

$Q_{all} = WH/[6(S+2.5)]$

For single-acting steam or air hammers and for diesel Hammers having unrestricted rebound of rams.

$Q_{all} = WH/[6(S+0.25)]$ (Use when driven weights are smaller than striking weights)

$Q_{all} = WH/[6\{S+0.25(WD/WS)\}]$ (Use when driven weights are larger than striking weights)

For double-acting steam or air hammers and diesel hammers having enclosed rams

Q_{all} = E/[6(S+0.25)] (Use when driven weights are smaller than striking weights).

Q_{all} = E/[6{S+0.25(WD/WS)}] (Use when driven weights are larger than striking weights)

In the above formulas:

Q_{all} = Allowable pile load in Kilograms.

W = Weight of striking parts of hammer in Kilograms.

H = The height of fall in centimeters for steam, and air hammers, and the observed average height of fall in centimeters, of blows used to determine penetration for diesel hammers with unrestricted rebound of hammer.

S = Average net penetration per blow in centimeters for the last 10 to 20 blows of steam, air, or diesel hammer; or for the last 15 centimeters of driving for a drop hammer.

E = The actual energy delivered by hammer per blow in Kilogram - centimeter.

WD = Driven weights in Kilograms

Note: Ratio of driven weights to striking weights should not exceed three.

WS = Weight of striking parts in Kilograms.

Modifications of basic pile driving formula:

a) For piles driven to and seated in rock as high capacity end-bearing piles: Drive to refusal (approximately four (4) to five (5) blows for the last 0.625 centimeters of driving). Re-drive open end pipe piles repeatedly until resistance for refusal is reached within two and half (2.5) centimeters of additional penetration.

b) For piles driven through stiff compressible materials unsuitable for pile bearing to an underlying bearing stratum:

Add blows attained before reaching bearing stratum to required blows attained in bearing stratum.

c) For piles driven into limited thin bearing stratum:

Drive to predetermined tip elevation, and determine allowable load by load test.

The bearing power as determined by the appropriate formula in the foregoing list will be considered effective only when it is less than the crushing strength of the pile. Other recognized formula for determining pile bearing power may be used when given in special specification. However, it shall be understood that the relative merits and reliability of any of the pile formula can be judged only on the basis of comparisons with the results of load tests.

407.3.2 Cast-in-Place Piles

Piles, cast-in-place, shall consist of one of the types either shown on the drawing and/or as specified. The term shaft wherever used in this section, shall mean either piles or shafts.

a. Working Drawings

At least 4 weeks before work on shafts is to begin, the Contractor shall submit to the Engineer for review and approval, an installation plan for the construction of drilled shafts. The submittal shall include the following:

i. List of proposed equipment to be used including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, sampling equipment, tremies or concrete pumps, casing etc.
ii. Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
iii. Details of shaft excavation methods.
iv. When slurry is required, details of the method proposed to mix, circulate and desand slurry.
v. Details of methods to clean the shaft excavation.
vi. Details of reinforcement placement including support and centralization methods.
vii. Details of concrete placement, curing and protection.
viii. Details of any required load tests.
ix. Other information shown on the plans or requested by the Engineer.

The Contractor shall not start the construction of drilled shafts for which working drawings are required until such drawings have been approved by the Engineer. Such approval will not relieve the Contractor of responsibility for results obtained by use of these drawings or any of his other responsibilities under the contract.

b. Fabrication of Permanent Lining

If shown on the drawings, the contractor shall provide a permanent lining suitably formed of ten (10) mm minimum thickness mild steel plate complying with B.S. 4360. The plates shall be cut and rolled to the inner diameter not less than the nominal diameter of the pile or such larger diameter as to allow the requisite pile diameter hole in the unlined length of pile. The rolled plates shall be connected by full penetration butt welds generally complying with B.S. 5133. No more than three (3) longitudinal seam welds shall be employed in any one cross-section and such welds shall be staggered in position in the cross-section between one length and the next. The dimensional accuracy of the lining shall be as stated on the drawings.

In the case of steel shells or pipes, after being driven and prior to placing reinforcing steel and concrete therein, the steel shells or pipes shall be examined for collapse or reduced diameter at any point. Any shell or pipe, which is improperly driven or broken or shows partial collapse to such an extent as to materially decrease its bearing value will be rejected. Rejected shells or pipes shall be removed and replaced, or a new shell or pipe shall be driven adjacent to the rejected one. Rejected shells or pipes, which can not be removed, shall be filled with lean concrete by the Contractor at his expense.

c. Piles Cast in Drill-Borehole

i) Boring Procedure

The method and equipment of boring generally either the dry method, wet method, temporary casing method or permanent casing method shall be one which maintains stability, verticality or batter (as shown on the Drawing) of the wall and base of borehole by the use of temporary casing and/or bentonite slurry.

All holes shall be drilled to the tip elevation shown on the Drawings, unless otherwise specified or approved by the Engineer. Rejected boreholes shall be filled with lean concrete by contractor at his expense.

The method shall be such that allows soil samples to be taken and in site soil test, (if required) to be carried out during or ahead of boring operations. The method/procedure used in execution of borehole and other operations shall not be such as to cause vibrations resulting in damage to completed or partially completed piles or to adjacent structures, services or other property. The procedure shall not be such as to cause harmful loosening or softening of soil outside the pile that has to be filled with concrete. The equipment used for execution of borehole shall be adequate to ensure that each pile penetrates to the required founding level.

- **Use of Casing**

  Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is poured. Casing, if used in drilling operations shall be removed from the hole as concrete is poured unless otherwise specified. The bottom of the casing shall be maintained not less than fifty (50) cm below the top of the concrete during withdrawal and pouring operations unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided.

- **Reinforcement**

  Reinforcement if called for shall conform to the requirements under item 404. The steel shells/pipes shall be of sufficient strength and rigidity to permit driving to the required bearing value or depth without injury. The steel may be either cylindrical or tapered, step tapered or a combination, plain, circular or fluted. All types shall conform to the corresponding ASTM standards. The minimum average tensile strength of steel shall be 3500 Kg/sq.cm (50,000 psi).

When called for on the Drawings or by the Engineer, the steel shells/pipes shall be factory coated on both interior or exterior surfaces by red lead paint conforming to AASHTO M-72 or as stated in the special specifications. The coating shall not cause any hindrance while assembling the pile section during welding operations.

ii) Temporary Casing Method

The temporary casing of appropriate diameter for locating the pile and piloting the borehole shall be pitched at the exact locations as given on the drawings to ensure that the casing when sunk is within the specified tolerances. The casing shall be sunk to sufficient depth by approved methods. The depth shall be at least sufficient to prevent the ingress of alluvium or other loose materials into the bore when executed below the bottom level of the casing. In addition, the depth shall be such as the contractor considers necessary for the stability of the casing and/or temporary works system during construction in general and for the following conditions and operations in particular during all conditions of river current which may occur during the period of works:

a: Open temporary casing to ensure against blow-in of soil.

b: Concreting of the pile, until temporary casing is extracted

- **Safety of Casing**

  The contractor shall take all such measures and provide such strengthening and bracing as is necessary and to the approval of the engineer to ensure that the temporary casing is not disturbed, overturned, over-stressed or under-eroded in any condition of temporary casing shall be such that it will not disturb the freshly cast concrete and/or permanent lining and/or reinforcement.

  Where the use of temporary casing is approved for the purpose of maintaining the stability and over-rapid withdrawal of the boring tools which could lead to excessive removal of soil and water and disturbance of the surrounding ground

and when boring through any permeable stratum (including silt), the water level in the boring shall be maintained between one (1) meter and two (2) meters above the external water level, unless the engineer directs otherwise.

The temporary casings shall be free from significant distortion and of uniform cross sections throughout each continuous length. During concreting they shall be free from encrusted concrete or any internal projections which might prevent the proper formation of the piles.

Permanent Casing Method

The permanent casing construction method shall be used when required by the plans. This method consists of driving or drilling a casing to a prescribed depth before excavation begins. If full penetration cannot be attained, the Engineer may require either excavation of material within the embedded portion of the casing or excavation of a pilot hole ahead of the casing until the casing reaches the desired penetration. In some cases, over-reaming to the outside diameter of the casing may be required in order to advance the casing.

The casing shall be continuous between the elevations shown on the plans. Unless shown on the plans, the use of temporary casing in lieu of or in addition to the permanent casing shall not be used except when authorized by the Engineer in writing.

After the installation of the casing and the excavation of the shaft is complete, the casing shall be cutoff at the prescribed elevation and the reinforcing steel and shaft concrete placed within the portion of the casing left in place.

iii) Bentonite Slurry

Where the use of bentonite slurry is approved for the purpose of maintaining the stability of the walls and base of bore, the contractor's proposals in accordance with (sub clause vi) hereof shall include details of the slurry. These shall include inter-alia:

a. The source of the bentonite
b. The constitution of the slurry.
c. Specific gravity, viscosity, sheer strength and PH value of slurry.

d. The methods of mixing, storing, placing, removal and recirculating the slurry, and
e. The provision of stand-by equipment.

Tests shall be carried out to ensure that the proposed constitution of the slurry is compatible with the ground water. Proposals for the constitution and physical properties of the slurry shall include average, minimum and maximum values. The specific gravity of the slurry shall not be less than one and three hundredth (1.03) in any case at any time. The contractor shall use additives where necessary to ensure the satisfactory functioning of the slurry.

Manufacturers Certificate

A manufacturer's certificate showing the properties of the bentonite powder shall be delivered to the Engineer for each consignment delivered to site. Independent tests shall be carried out at laboratory approved by the Engineer on samples of bentonite frequently.

Tests on Bentonite Slurry

The Contractor shall carry out tests during the course of the piling to check the physical properties of the bentonite slurry in the works. These tests shall include,

inter-alia, density, viscosity, shear strength and PH tests. The test apparatus and test methods shall be those given in "Recommended Practice" Standard by American Petroleum Institute, New York City, 1957, reference API RP29, Section- I, II and VI.

The frequency of tests shall be that which the Contractor considers necessary to ensure that the bentonite slurry is in accordance with his proposals and as such other times as the Engineer may direct.

Should the physical properties of any bentonite slurry deviate outside the agreed limits, such slurry shall be replaced, irrespective of the number of time it has been used by new bentonite slurry of correct physical properties.

Adequate time shall be allowed for proper hydration to take place, consistent with the method of mixing, before using slurry in the works.

Precautions

The Contractor shall control the bentonite slurry so that it does not cause a nuisance either on the site or adjacent waterways or other areas. After use it shall be disposed in a manner to the approval of the Engineer.

The level of the slurry in the bentonite shall be maintained so that the internal fluid pressure always exceeds the external water pressure.

If chiseling is used when boring through hard strata or to overcome obstructions, the stability of the excavation shall be maintained by methods acceptable to the Engineer.

iv) Excavation From Boreholes

The soil and debris from inside the pile boreholes shall be removed by bucket, augur or circulating bentonite slurry provided that no jetting at the foot of the borehole shall be permitted. Methods of excavation, which in the opinion of the Engineer may damage the permanent lining of the pile, shall not be employed.

Should the excavation reveal any soil stratum below the bottom of a pile which is, in the opinion of the Engineer, unsuitable for supporting the loads that will be imposed on it, the Contractor shall remove all such sub soil stratum to the satisfaction of the Engineer and shall lengthen the pile if necessary and cost of any such lengthening shall be paid as per this contract.

Excavation shall be carried out as rapidly as possible in order to reduce to a minimum the time in which any strata are exposed to the atmosphere, bentonite slurry or water. In any case, a pile shall not remain unfilled with concrete for period exceeding eighteen (18) hours after completion of borehole.

The materials from pile excavation shall be disposed so that the same does not interfere with any part of the permanent works of this project, in neat and workmanlike manner.

v) Samples and Tests

The Contractor shall take soil samples as given below or as directed by the Engineer to the designed tip elevation of the pile and shall carry out insitu Standard Penetration tests within, and ahead of borehole on the line of vertical axis of the pile at these locations after one and half (1.5) meter interval. The costs of tests and collection of samples shall be deemed to be included in the unit rates quoted by the Contractor. Each disturbed sample shall, as far as possible, be truly representative of the grading of insitu soil at the point from which it is taken, without contamination by other material. It shall be approximately five (5) Kg in weight and shall be placed

in a strong air tight container immediately after its removal from the sampler. The container shall be sealed as soon as the sample has been placed in and shall be taken to the site laboratory for grading, moisture content and Atterberg Limits tests.

The apparatus and procedure for the Standard Penetration Test shall be in accordance with the provisions of ASTM D 1586 Penetration Test and split-barrel sampling of soils and/or ASTM D 1587 thin-walled sampling of soils, (except insofar as any such provisions may conflict with other requirements of the contract).

vi) Limitations of Boring Sequence

Piles shall be constructed in such a manner and sequence as to ensure that no damage is sustained by piles already constructed in adjacent positions. The Contractor shall submit to the Engineer for his approval a programme showing sequence of construction of various piles.

vii) Tolerances

Following construction tolerances shall maintained

a. The drilled shaft shall be within 3 inches of the plan position in the horizontal plane at the plan elevation for the top of the shaft.
b. The vertical alignment of the shaft excavation shall not very from the plan alignment by more than 1/4 inch per foot of depth.
c. After all the shaft concrete is placed, the top of the reinforcing steel cage shall be no more than 6 inches above and no more than 3 inches below plan position.
d. When casing is used, its outside diameter shall not be less than the shaft diameter shown on the plans. When casing is not used, the minimum diameter of the drilled shaft shall be the diameter shown on the plans for diameters 24 inches or less, and not more than 1 inch less than the diameter shown on the plants for diameters greater than 24 inches.
e. The bearing area of bells shall be excavated to the plan bearing area as a minimum. All other plan dimensions shown for the bells may be varied, when approved, to accommodate the equipment used.
f. The top elevation of the shaft shall be within 1 inch of the plan top of shaft elevation.
g. The bottom of the shaft excavation shall be normal to the axis of the shaft within 3/4 inch per foot of shaft diameter.

viii) Inspection

After the borehole has reached its final stipulated positions, after the samples have been taken out, as required by the Engineer, and the borehole has been completely cleaned of all loose matter and otherwise made ready to receive the reinforcement and thereafter the concrete, the contractor shall so inform the Engineer.

The Engineer shall inspect the soil samples and test results thereon, check the elevation of the bottom of the borehole and the amount and direction, if any, by which the top of the casing is out of position, or out-of-plumb having satisfied himself on these and on any other points which he may consider relevant shall sign permission authorizing the Contractor to proceed with the placing of the reinforcement. The Contractor shall under no circumstances proceed with the placing of reinforcement or with the subsequent concreting without having first obtained the authority signed separately for each and every borehole by the Engineer.

ix) Pile Reinforcement

The reinforcement for each pile shall be assembled and securely tied by means of binding wire and by welded or spiral reinforcement rings as shown on the drawings, in such a manner as to form a rigid cage.

The required concrete cover to the reinforcement shall be maintained by suitable spacers securely attached to the reinforcement and of sufficient strength to resist damage during handling of the reinforcement cage into the pile. The distance between the spacers shall be such that the required cover is maintained throughout and that there is no displacement of the reinforcement cage in the course of the concreting operation.

Should the Contractor prefer to lower the reinforcement cage assembly into the borehole in sections, he may do so provided the same lapping requirements as for assembly on the ground are followed, namely, the longitudinal reinforcement shall be lapped as shown on the drawings and the spiral reinforcement shall be doubled over the lap zones. Spacers maintaining concrete cover shall be located immediately below and above the laps at 4 points spaced around the cage.

407.3.3 Concreting of Piles

In general, item 401 of the General Specifications shall be followed, however, the following particular requirements shall be observed.

i) Materials

Compressive strength of concrete in piles shall be of class A_3 as prescribed in Item 401, except if otherwise indicated.

Suitable retarder, plasticiser may be added as approved by the Engineer.

The Contractor shall submit the detailed proposed additive for approval, which shall be approved after laboratory trial mix results. The dosing of retarders shall ensure initial setting time of not less than five (5) hours corresponding to the ambient temperature at which the concreting is proposed to be carried out.

ii) Commencement of Concreting

Prior to placing any concrete

a. Any heavy contaminated bentonite slurry, which could impair the free flow of concrete from the tremie pipe, shall be removed.

b. Any loose or soft material/water soil shall be removed from the bottom of the bore by methods acceptable to the Engineer.

The Contractor shall not proceed with the concreting of the pile until the Engineer gives specific permit to do so after satisfying himself of the:

- Adequacy of the Contractors equipment and arrangement.
- Proficiency of his personnel.
- Cleanliness of the borehole.

Contractor shall have a suitable lighting arrangements at all times for inspecting the entire length of the shells, pipe or hole before placing the reinforcing steel or concrete.

Prior to the concreting a pile, sample of slurry shall be taken from the base of the borehole using an approved sampling device and its specific gravity shall be determined.

iii) Placing of Concrete

The tremie shall be of not less than two hundred and fifty (250) mm diameter made of water-tight construction. The means of supporting the tremie shall be such as to permit the free movement of the discharge end in the concrete in the pile. The tremie pipe shall be fitted with travelling plug, which shall be placed at the top of the pipe before charging the tremie pipe with concrete as barrier between the concrete and water or bentonite slurry, so as to prevent water or bentonite slurry entering the tube and mixing with the concrete. The tremie shall be carefully lowered into the borehole so that the end of the tube shall rest at about one hundred and fifty (150) mm above the bottom of the borehole, with reinforcement in the borehole, and the hopper end of the tremie tube shall be filled with concrete as aforesaid. It shall be slightly raised so that when the concrete reaches the bottom it flows out of the lower end of the tube, and fills the bottom of the borehole. Thereafter, the rate of withdrawal of the tremie shall be gradual so as to ensure the end of the tremie pipe is always one and half (1.5) meters below the top of the concrete in the borehole. An allowance shall be made for the top five hundred (500) mm of concrete in borehole during concreting being unsatisfactory. When the next batch is placed in the hopper the tremie shall be slightly raised but not out of the concrete at the bottom, until the batch discharges to the bottom of the upper. This operation shall be controlled by calculating the volume of concrete required to fill one linear meter of pile and then by measuring the rate of withdrawal of the tube corresponding to the volume of the batch in the hopper. The flow shall then the retarded by lowering the tube. The depth of the concrete in borehole shall be measured at intervals to keep a constant check that the tremie pipe bottom is immersed in concrete.

Concreting in each pile shall be carried out in a continuous operation without stoppages until the pile has been completed.

If the bottom of the tremie pipe ceases to be immersed in the body of the concrete in the pile and the seal is broken, concreting shall cease immediately and such remedial measures as the Engineer may accept or direct shall be carried out. The Contractor shall take precautions to ensure that the concrete is free of voids and shall prevent the entry of water and/or collapse of soil into concrete. If any soil or other deleterious or extraneous materials fall into any pile excavation prior to or during concreting, it shall be removed immediately.

Concreting shall continue until the concrete has reached an elevation five hundred (500) mm higher than the designated pile cut off level shown on the drawings, or as otherwise directed by the Engineer.

The concrete shall be placed in one continuous operation from tip of cut-off elevation and shall be carried out in such a manner as to avoid segregation. The method of placing the concrete and the consistency (slump) shall conform to the requirements of Item 401 or to the satisfaction of the Engineer.

No shell or pipe shall be filled with concrete until all adjacent shells, pipes or piles within a radius of three (3) M or five (5) times the pile diameter, whichever is greater, have been driven to the required resistance.

After a shell or pipe has been filled with concrete, no pile shall be driven within seven (7) meters thereof until at least seven (7) days have elapsed.

407.3.4 Withdrawal of Temporary Casing

If the method of construction involves partial withdrawal of temporary casing as concreting proceeds, a sufficient head of concrete shall be maintained above the bottom of the temporary casing to ensure that no voids are formed within the pile and to prevent the entry of ground water and to prevent the collapse of soil into the concrete.

If such entry or collapse should occur, the temporary casing shall be re-driven before the concrete has set and all defective concrete shall be removed or the construction of the pile shall be abandoned, in which case the provision of the clause herein which refers to "Defective Piles" shall apply.

The withdrawal of the temporary casing shall be carried out before the adjacent concrete has taken its initial set.

The method and timing of withdrawal must be such as to ensure that the space between the pile and the surrounding ground shall be filled with concrete.

407.3.5 Splicing of Piles

Splicing of piles, when permitted by the Engineer, shall be made as shown on the Drawings or as specified with materials having same quality and characteristic as for materials used for the pile itself.

i) Precast Concrete Piles

For precast concrete piles, the splicing shall be done according to one of the following methods unless otherwise specified.

1) Using prefabricated joints mounted in the forms and cast together with the pile sections and joined together as specified by the manufacturer and approved by the Engineer. The joints shall be of the design and type as shown on the Drawings.

2) By cutting away the concrete at the end of the pile, leaving the reinforcement steel exposed for a length of forty (40) times steel bar diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement of the same size as that used in the pile shall be welded to the projecting steel and the necessary formwork shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to placing concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement, or other suitable bonding material to the satisfaction of the Engineer. The forms shall remain in place not less than seven (7) days. The pile shall not be driven until the 28-days design strength is reached.

3) Any other method shown on the Drawings or approved by the Engineer.

ii) Steel Piles, Shells or pipes

For steel piles shells and pipe, the splicing shall be as under:

If the ordered length of the steel pile, pipe, or shell is insufficient to obtain the specified bearing value, an extension of same cross-section shall be spliced to it. Unless otherwise shown on the Drawings, splices shall be made by butt-welding the entire cross-section to form an integral pile using the electric arc method. The sections connected shall be properly aligned so that the axis of the pile will be straight. Piles bent or otherwise injured shall be rejected.

407.3.6 Cutting of Piles

Tops of piles shall be embedded in the concrete footing as shown on the drawings.

Concrete piles shall, when approved by the Engineer, be cut off at such a level that at least five (5) cm of undamaged pile can be embedded in the structure above. If a pile is damaged below this level, the Contractor shall repair the pile to the satisfaction of the Engineer. The longitudinal reinforcement of the piles shall be embedded in the

structure above to a length equal to at least (40) times the diameter of the main reinforcing bars. The distance from the side of any pile to the nearest edge of the footing shall not be less than twenty (20) cm.

When the cut-off elevation for a precast concrete pile, steel shell, pipe or for a cast-in-place concrete pile is below the elevation of the bottom of the pile cap, the pile may be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete construction according to Item 401, if approved by the Engineer.

Cut-offs of structural steel piles shall be made at right angles to the axis of the pile. The cuts shall be made in clean, straight lines and any irregularity due to cutting or burning shall be leveled off with deposits of weld metal prior to placing bearing caps.

407.3.7 Defective Piles

Any pile delivered with defects such as damaged during driving or cast insitu, placed out of its proper location, incapable or partially capable of permanently carrying the load which it is intended to carry, driven below the elevation fixed by the Drawing or by the Engineer, due to the immature setting of the concrete in the pile or due to caving/collapse of the borehole fully or partially, or due to any cause of which Engineer shall be sole judge to determine shall be corrected at the contractor's expense by one of the following methods approved by the Engineer:-

a) The pile shall be withdrawn and replaced by a new and when necessary, by longer pile.

b) A second pile shall be driven or cast adjacent to the defective pile.

c) The pile shall be spliced or built up as otherwise provided herein or the underside of the footing lowered to properly imbed the pile.

The contractor shall undertake such additional tests/works as the Engineer may specify to provide additional foundations to supplement the defective piles and so modify the structure to be supported as to ensure that load will be transferred safely to the additional foundations of existing pile. The contractor shall be responsible for the cost of such additional functions and tests and/or of the extra work carried out in such modification to the structure.

A concrete pile shall be considered defective if it has a visible crack or cracks, extending around the four sides of the pile, or any defect, which, in the opinion of the Engineer affects the strength, or life of the pile.

When a new pile is driven or cast to replace a rejected one, the Contractor, at his expense, shall enlarge the footing as deemed necessary by the Engineer.

407.3.8 Test Piles

Test piles which are shown on the Drawings or ordered by the Engineer shall conform to the requirements for piling as specified and shall be so located that they may be cut-off and become a part of the completed structure.

Test piles to be load tested in accordance with Item 407.3.9 shall be driven in locations determined by the Engineer. These piles shall not be utilized in the structure unless otherwise directed.

Test piles driven by the Contractor for his own use in determining the lengths of piles to be furnished may be so located and they may be cut-off and become a part of the completed structure provided that such test piles conform to the requirement for piling in these specifications.

Any pile, which after serving its purpose as a test pile is found unsatisfactory for utilization in the structure, shall be removed if so ordered by the Engineer, or if

approved by the Engineer it shall be cut-off below the ground line and footings, but such approval does not in any way relieve the Contractor of his responsibilities.

Test piles shall generally be driven with the same equipment that is to be used for driving foundation piles. When required, the ground shall be excavated to the elevation of the bottom of the footing before the test pile is driven.

When diesel hammers are to be used for driving end bearing piles, or friction piles where the bearing capacity shall be checked by pile driving formulas, the Contractor shall in advance carry out test piling or load tests to determine the energy developed by the hammer. The Contractor may elect one of the following methods for the calibration:

a) By test driving the same type of piles successively with diesel hammer and gravity or single acting hammer, or by driving two different piles with diesel hammer and gravity or single acting hammer respectively.

b) By driving test piles to a depth determined by the Engineer and load testing the same piles in accordance with Item 407.3.9.

c) Calibration tests shall be made at least at two different sites until the results are satisfactory to the Engineer.

Calibration of diesel hammers may not be required if the hammer has been previously calibrated under soil conditions and for the same size and type of pile, provided that the calibration data is accepted by the Engineer.

407.3.9 Load Tests

A load test shall consist of the application of a load equal to a minimum of 2 times the specified bearing capacity or as otherwise provided for herein or as directed by the Engineer. Load tests shall be made where specified and/or where called for by the Engineer. Unless otherwise permitted by the Engineer, the load tests shall be completed before the remaining piles in the same structure are driven or cast.

Load tests shall be made by methods approved by the Engineer. The Contractor shall submit to the Engineer detailed plans of the loading system and apparatus he intends to use at least three (3) weeks in advance. The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. Tension anchor piles if used, shall be of a design and driven to a depth satisfactory to the Engineer. Steel shells or piles whose walls are not of adequate strength to withstand the test loading when empty, shall have the required reinforcement and concrete placed before loading. The load test shall not be started until the concrete has attained a minimum compressive strength of ninety five (95) percent of the design twenty eight (28) days compressive strength. If he so elects, the Contractor may use high early strength cement in the concrete of the load test pile and the tension piles.

Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of three times the design load for the pile being tested. Reference points for measurement of pile settlement shall be sufficiently away from the test pile to preclude all possibility of disturbance.

All pile load settlements shall be measured by adequate devices, such as gauges, and shall be checked by means of an Engineer's level. Increment of deflection shall be read just after each load increment is applied and at 15-minute intervals thereafter. The safe allowable load shall be considered as 50 percent of the load which, after 48 hours of continuous application, has caused not more than 6 mm of permanent settlement, measured at the top of the pile.

The first load to be applied to the test pile shall be 50%, of the pile design load and the first increment shall be up to the pile design load by applying additional loads in three

equal increments. A minimum period of 2 hours shall intervene between the application of each increment, except that no increment shall be added until a settlement of less than one tenth (0.1) mm is observed for a 15-minute interval under the previously applied increment. If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by fifty (50) percent, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted. The full test load shall remain on the test pile not less than forty eight (48) hours. The full test load shall then be removed and the permanent settlement read.

When directed by the Engineer load tests shall then be continued beyond the double design load in 10-ton increments to failure or a maximum of three (3) times the design load.

The pile may be considered to have failed when, either the total permanent settlement exceeds six (6) mm, or total permanent settlement causes angular distortions between adjacent piles greater than 0.008 rad. (1/125) in simple spans, and 0.004 rad. (1/250) in continuous spans.

407.3.10 Backfilling Empty Boring

When each pile has been cast, the empty bores remaining shall not be back-filled unless required by the construction procedures and activities following the completion of piling work.

407.3.11 Pile Records

The Contractor shall keep records of the piles driven or installed. A copy of the record shall be given to the Engineer within two (2) days after each pile is driven. The record form to be used shall be approved by the Engineer. The pile records shall give full information as per the following table.

On completion of the piling for each structure, the Contractor shall deliver to the Engineer a drawing recording the exact location and the final depth (tip elevation) of all piles.

Driven Piles	Cast-in-Place Piles
Pile type and dimension.	Pile type and nominal dimensions.
Driving equipment, type, weight, efficiency of hammer etc.	Date of boring commenced, level reach-and reached each day and date of casting.
Date of casting (for concrete piles) and driving.	Soil samples taken from pile boring operation and soil test results.
Details of Reinforcement.	Strata and ground water encountered with levels, description shall be in accordance with B.S.C.P. 2001.
Test results on concrete	Length of finished pile and tip elevation
Depth driven & tip elevation.	Dia of borehole.
For gravity and single-acting hammers: the height of drop.	Elevation of the bottom of borehole.
For double acting hammers: the	Date of placing concrete;

frequency of blows.	theoretical and actual quantities of concrete used in pile.
Final set for last 20 blows for every 10 piles and when the Engineer so requires the penetration along the whole driven depth shall be recorded.	Lengths and diameter of temporary casing and permanent lining and the elevation of the tip of temporary casing and of permanent lining.
Details of any interruption in driving.	Details of Reinforcement.
Level of pile top immediately after driving, and the level when all group are driven.	Details of penetration during boring operation or driving of steel shell piles in the (driving records as for driven piles).
Details of re-driving.	Quality, consistency and other test results on concrete.
Any other relevant information.	Time interval between boring or driving and concreting.
	Any other relevant information.

407.3.12 Confirmatory Boring

The contractor shall carry out confirmatory boring at bridge site at locations indicated by the Engineer.

Boring shall be carried out with ASTM D 1586 Penetration Test and Split barrel sampling of soil. Additionally, when undisturbed sampling is required, the procedure shall conform to ASTM D 1587, Thin Walled sampling of soil.

Diameter of boreholes shall be twenty (20) centimeters cased through out its length and shall be down to the designated elevation. In-situ standard penetration test shall be carried out at one and half (1.5) meters interval from designated top elevation to the bottom of the hole. Undisturbed samples shall be taken from substratum. If clay is encountered, undisturbed samples will be taken at interval of three (3) meters.

At least two borings are required at each bridge site. The boring shall extend to a depth of at least three (3) meters below the pile tip elevation as indicated in the drawings.

407.4 MEASUREMENT AND PAYMENT

407.4.1 Measurement

The quantities to be paid for shall be the number of linear meters of piles, completed and accepted, measured from the pile tip elevation to the bottom of pile caps, footings or bottom of concrete superstructure in the case of

pile bents. In case the bottom of pile caps or footing or bottom of pile bent is above N.S.L and method of fabrication is such that the work above N.S.L is done as that of column, the same shall be measured as concrete and steel for column. No allowance shall be made for cut-offs or the required length of concrete or reinforcement steel placed into the concrete structure as called for on the drawings. Any additional pile lengths that may be necessary to suit the Contractor's method of operation or for any other reason shall not be included in the measurements.

- For cast-in-situ piles, helical and vertical steel will be measured in Tons. Pile casing where ever provided will be measured in linear meters. Measurement shall be

made for permanently placed pile casing as shown on drawings. If the Contractor likes to use temporary casing for the convenience of preparing of boreholes, the same shall not be measured whether left at site or withdrawn after completing the boreholes.

- Test piles when ordered by the Engineer, whether or not utilized as service piles in the structure shall not be included in the above measurements. Accepted test piles will be measured separately as the number of linear meters.

- Pile shoes when called for on the Drawings or by the Engineer shall be measured by the number accepted in place.

- Splicing of piles if not shown on the drawings will not be allowed except that the length of reinforcement is to exceed 12 meter in which case the splicing will not be measured or paid directly but the cost thereof shall be considered as included in the unit price for piling.

- Load tests shall be counted as the number of complete and accepted load tests as described in Item 407.3.9.

- Concrete footings or pile caps shall be measured and paid for as provided under Item 400 "Structures". Additional quantities of concrete, reinforcement and formwork caused by incorrect location of piles or additional piles necessary to replace defective piles shall be to the Contractor's expense.

407.4.2 Payment

- The quantities of piling left in place in the accepted structure measured as provided above shall be paid for at the contract unit price per linear meter of piles of the different types listed below and shown in the Bill of Quantities.

- For cost-in-situ piles, rate per linear meter will include all items except for helical and vertical reinforcement, which will be paid as per steel reinforcement item 404.

- For pre cast piles, the cost of steel shall be included in the rate per linear meter.

Pile casing will be paid at the contract unit price per linear meter for pile casing.

Test piles whether or not used in the completed structure or constructed adjacent to structure as per requirements of the contract document shall be paid for at the contract unit price for pile installation.

Load tests shall be paid for at the contract unit price for pile load Tests, either one and half (1.5) times or two (2) times the design load. The unit price for test loading to three (3) times the design load shall include the total load test with all load increments as described in Item 407.3.9.

Payment for tubular steel piles left in place shall include the cost of the concrete core of the specified class of concrete and the steel reinforcement of the said concrete core.

The quantity to be paid for confirmatory boring shall be the number of linear meters of the boring completed and accepted.

Such prices and payment shall be considered full compensation for furnishing all materials, performing standard penetration and all other relevant laboratory tests, labour, equipment, tools, fuel, welding, if needed and other incidental expenses including splicing, caging providing covers etc. necessary to complete the item as directed by the Engineer.

Pay Item No.	Description	Unit of Measurement
407 a	Cast in place concrete pile up to 1m dia.in normal soil (Boring only)	LM
407b	Pile load test up to 120 ton	NO
407c	Pile load test up to 240 ton	NO
407d	Pile load test up to 360 ton	NO
407e	Confirmatory boring (Nx size)	LM
407f	Permanente pile casing for piles	LM
407g	Cast in place concrete pile up to 1m dia in gravel soil (Boring only)	LM
407h	Cast in place concrete pile 1.1m to 1.5m dia in normal soil (Boring only)	LM
407i	Cast in place concrete pile 1.1m to 1.5m dia in gravel soil (Boring only)	LM
407j	Cast in place concrete pile 1.6m to 2.0m dia in normal soil (Boring only)	LM
407k	Cast in place concrete pile 1.6m to 2.0m dia in gravel soil (Boring only)	LM
407l	Pile load test up to 550 ton	NO
407m	Pile load test up to 800 ton	NO
407 n	Mobilization-demobilization Piling Rig	
	i. Up to 25kms	NO
	ii. 25 kms to 50 km	NO
	iii. Each km beyond 50 km	NO

SECTION 408 SHEET PILING

408.1 DESCRIPTION

This item shall consist of furnishing, driving, cutting off and removal, if required, of sheet piles in accordance with the Drawings, or as designated by the Engineer. Sheet piles for cofferdams in connection with foundations for structures shall be included in the unit price for Item 107-Structural Excavation. Sheet piling shall be a separate pay item only when stated in the Bill of Quantities.

408.2 MATERIAL REQUIREMENTS

408.2.1 Timber Sheet Piles

The timber, unless otherwise definitely noted on the Drawings or in the Special Provisions, may consist of any species, which will satisfactorily stand driving. It shall be sawn or hewn with square corners or with tongue-and-groove joint as directed by the Engineer and shall be free from holes, loose knots, wing shakes, decay or unsound portions, or other defects which might impair its strength or tightness.

408.2.2 Concrete Sheet Piles

Concrete, reinforcement, and manufacture of Concrete Sheet Piles shall conform to the Specifications governing Precast Concrete Piles under Item 407 - Piling. Joint details shall be as indicated on the Drawings.

408.2.3 Steel Sheet Piles

Steel Sheet piles shall be of the type and weight indicated on the Drawings. The steel shall conform to AASHTO M 223 or ASTM A 572. Permanent steel sheet piles shall be coated with red lead paint conforming to AASHTO M 72 as instructed by the Engineer.

408.2.4 Bracing

Bracings or anchors for sheet piles shall be made of wood or steel according to the Drawings or as designated by the Engineer.

For temporary sheet piling like cofferdams for excavations, the Contractor shall be solely responsible for the design and construction of the bracing. The Drawings shall have the approval of the Engineer, but such approval does not in any way relieve the Contractor of his responsibility.

408.3 CONSTRUCTION REQUIREMENTS

408.3.1 Installation

Timber and concrete sheet piles shall be sharpened at their lowest ends.

All sheet piles shall be driven to the elevation shown on the Drawings or as directed by the Engineer. Where it is impossible to drive to the elevation shown on the Drawings due to sub-surface conditions, the piles may be stopped at a higher elevation with the written permission of the Engineer. However, before granting such permission the Engineer shall investigate to ascertain that the Contractor has adequate equipment for the required driving and that the piles can not be driven to the elevation shown with the proper use of this equipment.

The tops of a permanent sheet piling shall be driven or cut-off to a straight line at the elevation indicated on the Drawings.

The requirements governing the installation of sheet piling shall conform to those governing piles as set forth under Item 407.3.3 and 407.3.11.

408.3.2 Removal

Temporary sheet piling shall be removed or cut off at the stream bed or the original ground when directed by the Engineer.

In case when the Engineer orders sheet piling to be left in place for erosion protection, the Contractor and the Engineer shall agree on an equitable price.

408.4 MEASUREMENT AND PAYMENT

408.4.1 Measurement

When stated as a separate pay item in the Bill of Quantities, sheet piling will be measured by the square meters of sheet piling or as a Lump Sum as shown on the Drawings or directed in writing by the Engineer, complete in place and accepted. Measurement of piling, which has been delivered according to Drawings and cannot be driven to the directed elevation because of subsurface conditions shall be measured to the driven elevation.

408.4.2 Payment

Payment of Timber Sheet Piles, Concrete Sheet Piles and Steel Sheet Piles as determined under measurement shall be made at the contract unit price per square meter or as a Lump Sum for the pay items listed below and shown in the Bill of Quantities. Such prices and payment shall be considered full compensation for all materials, labour, equipment, tools paint, bolts, Wales and incidentals necessary to complete the item. All necessary bracings, whether shown on the drawings or not, shall be included in the contract price.

The under mentioned pay items and prices shall not apply to the equitable rate for sheet piling left in place for erosion protection according to Item 408.3.2.

Pay Item No.	Description.	Unit of Measurement
408a	Timber Sheet Piles	SM
408b	Concrete Sheet Piles	SM
408c	Steel Sheet Piles	SM

SECTION 409 WELL FOUNDATION

409.1 DESCRIPTION

This item shall consist of performing all operations in connection with the construction of a well to be used as a foundation for a pier or abutment. The work shall be comprised of five separate main operations: 1) casting of well kerb in proper position. 2) erection of well steening by stages 3) sinking of the erected kerb and well steening to the required elevation. 4) proper plugging of the well, and 5) construction of the transom slab all in accordance with specifications, and the Drawings or as directed by the Engineer.

409.2 MATERIAL REQUIREMENTS

409.2.1 Structural Steel

Structural steel shall conform to the requirements of AASHTO M 183 (ASTM DESIGNATION: A 36 unless otherwise specified).

409.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirements under item 404 Steel Reinforcement.

409.2.3 Structural Concrete

Structural concrete shall conform to Class A concrete requirements as specified under Item 401-Concrete.

409.2.4 Brickwork

Brick work shall conform to the requirements as specified under Item 410-Brick Masonry of these specifications.

409.2.5 Fill Sand

Fill sand shall consist of natural sand free from organic or deleterious materials subject to the approval of the Engineer and as specified and shown on the Drawings.

409.3 CONSTRUCTION REQUIREMENTS

409.3.1 Construction Equipment

All equipment to be used in construction shall be at Site in first class working condition and shall be approved by the Engineer before construction is started.

The number of units, the sizes, etc., of all equipment shall be adequate to ensure completion of the work within the time specified in the Contract or agreed by the Engineer.

No equipment shall be removed from the Site without the written approval of the Engineer.

All equipment, tools and machinery used shall be maintained in a satisfactory working condition throughout the required period of their use.

409.3.2 Structural Steel Work

(a) Notice of Rolling and Fabrication The contractor shall give ample advance notice to the Engineer of the beginning of the work at the mill and shop, so that inspection may be arranged accordingly. No material shall be rolled or fabricated before the Engineer has been notified, where the orders have been placed.

(b) Facilities for Inspection The Contractor shall furnish all facilities for the Inspection of materials and workmanship in the mill and shop, and Engineer's Rep. shall be allowed free access to the necessary areas of the premises.

(c) Inspection of Fabricated Work at Site The Engineer may waive shop inspection and make complete inspection of all fabricated work upon its delivery at the Site of structure. All structural steel works shall conform to the applicable ASTM requirements as shown under item 413. In case these requirements are not met, the material thus fabricated shall be rejected.

(d) Handling Members The field assembling of the component parts of the structure shall be done by the use of twisting, bending or otherwise deforming the metal. No members slightly bent or twisted shall be put in place until their defects are corrected and any members seriously damaged in handling will be rejected.

(e) Finish of Structural Steel Work The workmanship and finish shall be first class and equal to the best practice in modern bridge shops. Shearing and clipping shall be done neatly and accurately and all portions of the work exposed to view shall be neatly finished.

409.3.3 Special Construction Operations

(a) Casting Well Kerbs The cutting edge of the well kerb will be structural steel pre-fabricated and supplied in segments convenient for Site assembly by bolting together as per lines and dimensions shown on the Drawings. The segments of the cutting edge shall be interchangeable. The fitting together shall be checked at the site of fabrication work by the assembly of at least two complete cutting edges, formed of segments chosen at random before these are accepted for dispatch to the site of work. None of the steel work is to be painted and no surface preparation is called for other than the removal of the rust and loose adhering mill scale.

Reinforcing steel work in the cutting edge will be properly bolted to the steel work and placed and assembled as shown on the Drawings.

Structural concrete for the cutting edge will be of the required strength and shall be finished to the form and dimensions shown on the Drawings.

(b) Well Steening Well steening shall be made either of brick work in (1:3) cement mortar or Portland cement concrete of the required strength and of the form and dimensions as shown on the Drawings.

Reinforcing steel work will continue from the cutting edge into the well steening with spacers made of structural steel work consisting of mild steel plates of the size and dimension as shown on the Drawings.

(c) Well Sinking: Well sinking includes all operations required to sink the well in position and to the required elevation.

(1) Positioning: Each well kerb shall be correctly positioned in place and approved by the Engineer before commencement of further work.

(2) Support: Well kerb shall be adequately supported to prevent shift or tilt during the initial operation and on excavation and sinking whether the well has been started on made up ground or in water in excavation.

(3) Excavation of Sinking: The soil from inside the well shall be removed by mechanical grabbing or by other devices as approved by the Engineer. The accuracy of the sinking will be the responsibility of the Contractor.

(4) Dewatering: The Contractor will be required to pump out the water from inside the wells in such a way as shall be approved by the Engineer; but notwithstanding any

dewatering aid that the Contractor may use to assist in the operation of sinking the wells, the safety of plant and labour will remain the responsibility of the Contractor.

(5) Limits of Tilt and Shift: The limit of departure from true vertical position of any well shall not exceed one unit measured horizontally in a vertical distance of sixty units.

The maximum horizontal displacement of any well away from its correct position shall not exceed twenty (20) cm.

(6) Correcting Tilt etc: It will be entirely the responsibility of the Contractor to keep the tilt and shift within the specified tolerances. If the above limits are exceeded, the Contractor will be required to adopt measures to overcome the adverse affects of such shifts and tilts. In any case maximum pressure at the base of foundations after accounting for all shifts and tilts shall remain within the specified limits. The measures taken shall be allowed only after its approval has been received from the Engineer.

(7) Kentledge: The use of rails and other heavy weights is permissible in well sinking and in correcting error of tilt and horizontal displacement. But the Contractor must take care not to damage the well in the process; and in any case he must obtain the approval of the Engineer for his proposed method.

(8) Limits of Well Sinking: Each and every well shall be sunk to the level indicated on the Drawings. But in no case shall the Contractor stop well sinking unless he has first obtained the approval of the Engineer.

(d) Plugging of Well: When the well has reached the final elevation to which it is to sink and has been approved by the Engineer, the bottom of the well will be plugged by the depositing concrete of the required strength.

(1) Concrete Under Water: The concrete deposited under water shall have ten (10) percent excess cement. To prevent segregation it shall be carefully placed in the final position by means of a dump bucket or other approved method and shall not be disturbed after being deposited. The concrete shall be placed under the supervision of the Engineer.

(2) Continuous Placing: The concrete shall be placed in one continuous operation.

(e) Sand Filling: When the well bottom has been plugged, the well hole will be filled with sand as specified and shown on Drawings. The sand shall be free from deleterious materials.

(f) Transom Slab: When the well bottom has been plugged, the well top will be provided with a transom slab made of structural concrete of required strength, and reinforcing steel work, all according to the lines, dimensions and form shown on the Drawings.

409.4 SAMPLING AND TESTING

The Contractor will have adequate arrangements to the satisfaction of the Engineer to collect disturbed samples of soil at every one and half (1.5) meter elevation and at every change of soil strata and to deliver it in proper bags to the representative of the Engineer.

The Contractor will also be required to obtain three samples of the natural soil at the elevation at which the well kerb has been stopped and another sample three(3) meters below that elevation before he is allowed to plug the well.

409.5 MEASUREMENT AND PAYMENT

409.5.1 Measurement

a) General

For the various items of work constructed under this Item, measurement shall be made as narrated under the respective items. The quantity to be paid for shall be the original planned quantity measured as provided for respective items, except where changes have been made by the Engineer and order has been given in writing.

No measurements for or other allowances will be made for work or materials for forms, false works, supports, bracings, kentledge or pumping.

b) Structural Steel

The quantity of structural steel entering into and becoming a part of the completed structure, and accepted by the Engineer shall be the computed weight in metric tons of this material entering into the completed structure of item of work.

The unit of measurement of structural steel work shall be metric tons.

The weights of the rolled shapes, bars, plates and pipe railing shall be computed on the basis of nominal weight as given in the manufacturer's hand books, using the dimensions shown on the drawings. The weight shall be computed on the basis of dimensions and ordered overall lengths for all structural shapes. No deductions from the computed weight of rolled steel shall be made for caps, clips, sheared edges, punching borings, drillings, milling or planning and no allowance shall be made for the weight of weld metal or for overrun in weight.

c) Reinforcing Steel

For well kerb, steening and transom slab reinforcing steel shall be measured and paid for according to the requirements of Item 404.

d) Structural Concrete

For well kerb, steening, plugging of well and transom slab construction, concrete shall be measured and paid for according to the requirements under Item 401. The unit rate includes the cost of ten (10) percent extra cement to be used where required.

e) Brick Work

In (1:3) cement mortar for steening shall be measured and paid for according to the requirements of Item 410.

f) Well Sinking

For any item of work carried out under this head, measurement shall be made per linear meter of twin or single well of specified external diameter, sunk below the bed level shown on the Drawings. The unit of measurement shall be one linear meter. The unit rate for sinking twin or single well shall include excavation, pumping, supports, bracings, kentledge, tilt correction soil samples, all according to the requirements given in Item 409.3.3 and 409.4.

g) Fill Sand

The well hole shall be measured as the volume of well hole required to be filled. The unit of measurement shall be in cubic meters.

409.5.2 Payment

Payment will be made in accordance with the unit price in the Bill of Quantities for the various items in accordance with the specifications and shall constitute full compensation for furnishing all material, equipment, and labour and for performing all operations necessary to complete the work. Provision delivery of materials to Site, handling and storage and all incidentals shall be included in unit prices for various items.

SECTION 410 BRICK MASONRY

410.1 DESCRIPTION

This work shall consist of furnishing all materials, equipment and labour required for constructing brickwork as shown on the drawings and in accordance with these specifications.

410.2 MATERIAL REQUIREMENTS

410.2.1 Portland Cement

Portland cement shall conform to the requirements set forth under item 401.2.1.

410.2.2 Sand

Sand for mortar used in brickwork shall conform to the requirement for the fine aggregate specified in item 401.2.2 except that the grading shall be according to AASHTO M 45.

410.2.3 Water

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, salts or other impurities. No water shall be used without the approval in writing of the Engineer.

410.2.4 Mortar

The mortar for all brickwork shall consist of one (1) part of Portland cement to three (3) parts of sand by volume and of sufficient water to produce the proper consistency for the intended use.

410.2.5 Bricks

The size of the bricks shall be standard size (9"x4 1/2"x3")22.86 cm x 11.43 cm x 7.62 cm. They shall be well-burnt without being vitrified. They shall be of uniform colour, regular in shape and size with sharp and square corners and parallel faces. They must be homogeneous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 140.62 kg/sq.cm (2000 psi).

410.3 CONSTRUCTION REQUIREMENTS

410.3.1 Mixing of Mortar

Methods and equipment used for mixing mortar shall be such that each ingredient entering into the mortar shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time after all the ingredients are in the mixer, except the full amount of water, shall be not less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use. All mortar not used within thirty(30) minutes after addition of the water to the mix shall be wasted. Retempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work.

410.3.2 Brick Laying

Brick work shall not be placed during heavy or prolonged rain to wash the mortar from the bricks. Mortar already spread, diluted by rain shall be removed and replaced before restoring the work.

All bricks to be used in brickwork with mortar joints shall be immersed in water from three (3) to four (4) hours before use.

All bricks shall be skillfully laid with level courses, uniform joints, square corners, plumb verticals and true surface, except where otherwise shown on the Drawings.

All walls and abutments shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets can be obtained and shall be spaced not more than two (2) meters center to center.

All surfaces exposed to weather, shall be struck pointed to give a good workmanlike appearance and to seal the cavities in mortar joints.

410.3.3 Curing

All brickwork shall be cured for at least seven (7) days after laying. The curing method shall be to the satisfaction of the Engineer.

410.4 MEASUREMENT AND PAYMENT

410.4.1 Measurement

Measurement of brickwork shall be made to the lines of the structures as shown on the Drawings or as modified by the Engineer for the appropriate items in which such brickwork is incorporated.

The quantities to be measured shall be the number of cubic meters of brickwork laid and accepted.

410.4.2 Payment

The quantities measured as provided above shall be paid for at the contract unit price listed below and shown in the Bill of Quantities, which prices and payment shall be full compensation for furnishing all materials, labour, equipment and incidentals for performing all the work involved under this item:

Pay Item No.	Description	Unit of Measurement
410 a	Brick work with mortar ratio (1:6)	CM
410 b	Brick work with mortar ratio (1:4)	CM

SECTION 411 RANDOM AND DRESSED UNCOURSED STONE MASONRY

411.1 DESCRIPTION

The item shall consist of Random and Dressed uncoursed Stone Masonry with or without mortar. Dimensions of such masonry may vary as per drawings or as directed by the Engineer.

411.2 MATERIAL REQUIREMENTS

411.2.1 Stone

Random or dressed stone shall be of approved quality, sound and durable, free from segregation's, seams, cracks and other structural defects or imperfection tending to reduce its resistance to weather. It shall be free from rounded or weathered surfaces.

411.2.2 Mortar

Mortar for laying stone and pointing shall be composed of one part of Portland cement and four parts of sand unless otherwise shown on the drawings. Portland cement shall meet the requirements of AASHTO M-85 and sand shall meet the requirements of AASHTO M-45. Water used in preparation of mortar shall conform to the requirement set forth under item 401.2.7.

411.2.3 Filter Material

Filter material shall comprise of 4” (100 mm) down, well graded gravel, with voids filled with coarse sand.

411.3 CONSTRUCTION REQUIREMENTS

411.3.1 Stone Size and Shape

Individual stones shall have a thickness of not less than twenty (20) cms and a width of at least one and a half (1.1/2) times the thickness and length of at least one and a half (1.1/2) times their width.

Shape of stones may be irregular in random masonry, however for dressed uncoursed masonry, stones shall be cut in such a way that a well locked masonry can be laid. The size and shape of ring stones for arches shall be as shown on the drawings.

411.3.2 Dressing of Stones

For "A-Class" Masonry, Stones shall be dressed to exact sizes and shapes and cut to lay on beds with top and bottom truly parallel. Hallow beds shall not be permitted. Beds of face stone shall be fine finished for a depth of not less than thirty (30) centimeters. Vertical joints of face stone shall be fine finished and full to the square for a depth of not less than twenty five (25) centimeters.

Exposed surfaces of face stone shall be according to the plans, with edges pitched to true lines and exact batter, chisel drafts four (4) centimeters wide shall be cut at all exterior corners.

Stones for B-Class Stone Masonry shall be roughly squared on joints, beds and faces. Selected stones, roughly squared pitch to line shall be used at all angles and ends of wall.

411.3.3 Stretchers

Stretcher shall have a width of bed not less than one and a half (1.1/2) times their thickness, and length of bed not less than twice nor more than three and half (3.1/2) times their thickness but in no case less than ninety centimeters. Stone masonry in cement mortar shall be cured for at least seven (7) days.

411.3.4 Headers

Header, placed in each course, shall have width not less than one and a half (1.1/2) times their thickness. In walls having thickness of 1.2 meters or less, the headers shall extend entirely through the wall. In walls of greater thickness, the length of headers shall be not less than two and a half (2.1/2) times their thickness when the course is forty five (45) centimeters or less in height, and not less than 1.2 meters in courses of greater height. Header shall bond with the core or backing not less than thirty (30) centimeters. Header shall hold in the heart of the wall spaced not further a part than 2.5 meters center to center. There shall be at least one header to every two stretchers.

411.3.5 Cores and Backing

Core and backing shall consist either of roughly bedded and jointed headers and stretchers, as specified above or concrete as may be specified. When stone is used for cores of backing, at least one-half (1.1/2) of the stone shall be of the same size and character as the face stone and with parallel ends. No course shall be less than twenty (20) centimeters thick. Concrete used for cores and backing shall conform to the requirements specified in Item 401. The headers and stretchers in walls, having a thickness of one meter or less shall have a width or length equal to the full thickness of the wall. No backing will be allowed.

411.3.6 Laying Stone

It shall conform to the requirement as specified in Item 412.3.7.

411.3.7 Arches

Refer to Item No.412.3.12.

411.3.8 Weep Holes

Weep holes shall be made from well compacted filter material with minimum dimensions 30 cm x 30 cm x 30 cm or as shown in drawings. Filter material will be placed behind the retaining wall with uPVC pipe in the retaining wall to drain out water.

411.4 MEASUREMENT AND PAYMENT

411.4.1 Measurement

The quantity of stone masonry to be paid for shall be the number of cubic meters measured in the completed work and the limiting dimensions shall not exceed than those shown on the drawings or fixed in writing by the Engineer.

Class C or lean concrete shall be measured separately as per dimensions shown on the drawings or as directed by the Engineer. No separate measurement shall be made for stuck pointing which is deemed to be included in stone masonry with mortar, however roll pointing shall be measured separately in square meter.

411.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the B.O.Q., which price and payment shall be full compensation for labour, materials, equipment and incidentals to complete the item as described above

Pay Item No.	Description	Unit of Measurement
411 a	Stone masonry random dry	CM
411 b	Stone masonry random with mortar ratio (1:6)	CM
411 c	Stone masonry dressed un coursed dry	CM
411 d	Stone masonry dressed un coursed with mortar ratio (1:6)	CM
411 e	Roll pointing	SM
411 f	Stone masonry random with mortar ratio (1:4)	CM
411 g	Stone masonry dressed un coursed with mortar ratio (1:4)	CM
411 h	Filter media behind retaining and breast wall to protect the weep holes from blockage etc. complete in all respect	CM

SECTION 412 DRESSED COURSED STONE MASONRY

412.1 DESCRIPTION

This item shall consist of Dressed coursed stone masonry with mortar. Dimensions of such masonry may vary as per drawings or as directed by the Engineer.

412.2 MATERIAL REQUIREMENTS

412.2.1 Stone Size

The individual stones shall be large and well proportioned. They shall not be less than twenty (20) nor more than fifty (50) cms in thickness. The thickness of courses, if varied, shall diminish regularly from bottom to top of wall. The size of ring stones in arches shall be as shown on the plans.

412.2.2 Mortar

Mortar shall conform to the requirement set forth under Item 411.2.2.

411.2.3 Filter Material

Filter material shall comply with Item 411.

412.3 CONSTRUCTION REQUIREMENT

412.3.1 Surface Finishes of Stone

For the purpose of this specification the surface finishes of stone are defined as follows:-

Smooth-finished: Having a surface in which the variations from the pitch line do not exceed 0.15 cm.

Rough-finished: Having a surface in which the variations from the pitch line do not exceed 1.25 cm.

Scrabbled: Having a surface in which the variations from the pitch line do not exceed two (2) cm.

Rock-faced: Having an irregular projecting face without indication of tool marks. The projections beyond the pitch line shall not exceed seven and half (7.5) cm and no part of the face shall recede back of the pitch line.

412.3.2 Stone Dressing

Stones shall be dressed to exact sizes and shapes before being laid and shall be cut to lie on their natural beds with top and bottom truly parallel. Hollow beds will not be permitted. The bottom bed shall be the full size of the stone and no stone shall have an overhanging top. In rock-face construction the face side of any stone shall not present an undercut contour adjacent to its bottom axis giving a top-heavy, unstable appearance when laid.

Beds of face stone shall be fine-finished for a depth of not less than thirty (30) cm.

Vertical joints of face stone shall be fine-finished and full to the square for a depth of not less than fifteen (15) cm.

Exposed surfaces of the face stone shall be given with the surface finish indicated on the plans, with edges pitched to true lines and exact batter, Chisel drafts four (4) cm wide shall be cut at all exterior corners. Face stone forming the starling or nosing of piers shall be rough-finished unless otherwise specified.

Holes for stone hooks shall not be permitted to show in exposed surfaces.

412.3.3 Stretchers

Stretchers shall have a width of bed of not less than one and half (1.1/2) times their thickness. They shall have a length of bed not less than twice nor more than three and half (3.1/2) times their thickness, and not less than ninety (90) cm.

412.3.4 Headers

Headers shall be placed in each course and shall have a width of not less than one and half (1.1/2) times their thickness. In walls having a thickness of 1.2 meters or less, the headers shall extend entirely through the wall. In walls of greater thickness, the length of headers shall be not less than two and half (2.1/2) times their thickness when the course is forty five (45) cm. or less in height, and not less than 1.2 meters in courses of greater height. Headers shall bond with the core or backing not less than thirty (30) cm. Headers shall hold in the heart of the wall the same size shown in the face and shall be spaced not further apart than 2.5 meters center to center. There shall be at least one header to every two stretchers.

412.3.5 Cores and Backing

Cores and backing shall consist either of roughly bedded and jointed headers and stretchers, as specified above, or concrete, as may be specified.

When stone is used for cores of backing, at least one-half of the stone shall be of the same size and character as the face stone, and with parallel ends. No course shall be less than twenty (20) cm. thick.

Concrete used for cores and backing shall conform to the requirements specified in Item 401.

The headers and stretchers in walls having a thickness of one meter or less shall have a width or length equal to the full thickness of the wall. No backing will be allowed.

412.3.6 Mixing Mortar

The mortar shall be hand or machine mixed, as may be required by the Engineer. In the preparation of hand-mixed mortar, the sand and cement shall be thoroughly mixed together in a clean, tight mortar box until the mixture is of uniform colour, after which clean water shall be added in such quantity as to form a stiff plastic mass. Machine-mixed mortar shall be prepared in an approved mixer and shall be mixed not less than one and half (1.1/2) minutes. Mortar shall be used within forty five (45) minutes after mixing. Retempering of mortar will not be permitted.

412.3.7 Laying Stone

(a) General

Stone masonry shall not be constructed in freezing weather or when the stone contains frost, except by written permission of the Engineer and subject to such conditions as he may require. Stone Masonry in Cement mortar shall be cured for a minimum period of seven (7) days.

(b) Face Stone

Stone shall not be dropped upon, or slid over the wall, nor will hammering, rolling, or turning of stones on the wall be allowed. They shall be carefully set without jarring the stone already laid and they shall be handled with a Lewis or other appliance that will not cause disfigurement.

Each stone shall be cleaned and thoroughly saturated with water before being set and the bed, which is to receive it, shall be cleaned and well moistened. All stones shall be well bedded in freshly made mortar and settled in place with a suitable wooden maul before the setting of the mortar. Whenever possible, the face joints which can not be so pointed shall be prepared for pointing by raking them out to a depth of five (5) cm. before the mortar has set. The face surfaces of stones shall not be smeared with the mortar forced out of the joints or that used in pointing. No pinning up of stones with spawls will be permitted in beds.

Joints and beds shall be not less than one (1) cm. nor more than one and quarter (1.1/4) cm. in thickness and the thickness of the joint or bed shall be uniform throughout.

The stone in any one course shall be placed so as to form bonds of not less than thirty (30) cm. with the stones of adjoining courses. Headers shall be placed over stretchers and, in general, the headers of each course shall equally divide the spaces between the headers of adjoining courses, but no headers shall be placed over a joint and no joint shall be made over a header.

(c) Stone Backing and Cores

Stone backing shall be laid in the same manner as specified above for face stone, with headers interlocking with face headers when the thickness of the wall will permit. Backing shall be laid to break joints with the face stone. Stone cores shall be laid in full mortar beds so as to bond not less than thirty (30) cm. with face and backing stone and with each other. Bed joints in cores and backing shall not exceed 4.5 cm. and vertical joints shall not exceed ten (10) cm. in thickness.

(d) Concrete Cores and Backing

The operations involved in the handling and placing of concrete used in cores and backing shall conform to the requirements specified in Item 401. However, the puddling and compacting of concrete adjacent to the ashlar masonry facing shall be done in a manner that will ensure the filling of all spaces around the stones and secure full contact and efficient bond with all stone surfaces.

412.3.8 Leveling Courses

Stone cores and backing shall be carried up to the approximate level of the face course before the succeeding course is started.

The construction joints produced in concrete cores or backing by the intermittent placing of concrete shall be located, in general, not less than fifteen (15) centimeters below the top bed of any course of masonry.

412.3.9 Resetting

In case any stone is moved or the joint broken, the stone shall be taken up, the mortar thoroughly cleaned from bed and joints, and the stone reset in fresh mortar.

412.3.10 Dowels and Cramps

Where required, coping stone, stone in the wings of abutments, and stone in piers shall be secured with wrought-iron cramps or dowels as indicated on the plans.

Dowel holes shall be drilled through each stone before the stone is placed and, after it is in place, such dowel holes shall be extended by drilling into the underlying course not less than fifteen (15) cm.

Cramps shall be of the shapes and dimensions shown on the plans or approved by the Engineer. They shall be inset in the stone so as to be flush with the surfaces.

Cramps and dowels shall be set in lead, care being taken to completely fill the surrounding spaces with the molten metal.

412.3.11 Copings

Stones for copings of wall, pier, and abutment bridge seats shall be carefully selected and fully dimensioned stones. On piers, not more than two stones shall be used to make up the entire width of coping. The copings of abutment bridge seats shall be of sufficient width to extend at least ten (10) cm. under the back-wall. Each step forming the coping of wingwall shall be formed by a single stone, which shall overlap the stone forming the step immediately below it at least thirty (30) cm.

Tops of copings shall be given a bevel cut at least five (5) cm. wide, and beds, bevel cuts, and tops shall be fine-finished. The vertical joints shall be smooth-finished and the coping shall be laid with joints not more than 0.6 cm in thickness. The undersides of projecting copings, preferably, shall have a drip bead.

Joints in copings shall be located so as to provide not less than a thirty (30) cm. bond with the stones of the under course and so that no joint will come directly under the superstructure masonry plates.

412.3.12 Arches

The number of courses and the depth of voussoirs shall be as shown on the plans. Voussoirs shall be placed in the order indicated, shall be full size throughout, dressed true to template, and shall have bond not less than the thickness of the stone. Beds and joints shall be fine-finished and mortar joints shall not exceed two (2) cm. in thickness. Exposed surfaces of the intrados and arch ring shall be given the surface finish indicated on the plans.

Backing may consist of concrete as specified or of large stones shaped to fit the arch, bonded to the spandrels, and laid in full beds of mortar. The extrados and interior faces of the spandrel walls shall be given a finishing coat of one ratio three (1:3) cement sand mortar which shall be trawled smooth to receive the waterproofing.

Arch centering, waterproofing, drainage, and filling shall be as specified for concrete arches.

412.3.13 Pointing

Pointing shall not be done in freezing weather nor when the stone contains frost.

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar after proper raking. The mortar shall be well driven into the joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done and in hot or dry weather the pointed masonry shall be protected from the sun and kept wet for a period of at least 3 days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

411.3.14 Weep Holes

Weep holes shall comply with Item 411.

412.4 MEASUREMENT AND PAYMENT

412.4.1 Measurement

The quantity of stone masonry to be paid shall be the number of cubic meters measured in the completed work and the limiting dimensions shall not exceed than those shown on the drawings or fixed by the Engineer.

Concrete Class-C or lean shall be measured separately as per dimensions shown on the drawings or as directed by the Engineer. No separate measurement shall be made for stuck pointing, which is deemed to be included in stone masonry with mortar, however roll pointing shall be measured separately in square meters. No separate measurement will be made for dowels and cramps.

412.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the B.O.Q., which price and payment shall be full compensation for labour, materials, tools, equipment and incidentals to complete the item as described above. Dowels and cramps shall be considered as subsidiary item.

Pay Item No.	Description	Unit of Measurement
412 a	Stone masonry dressed coursed with mortarratio (1:6)	CM
412b	Stone masonry dressed coursed with mortarratio (1:4)	CM

SECTION 413 STEEL STRUCTURES

413.1 DESCRIPTION

413.1.1 General

This work shall consist of steel structures and the steel structure portions of composite structures, constructed in conformity with the lines, grades and dimensions shown on the drawings or as established by the Engineer.

The work will include all labour, materials and equipment required to furnish, fabricate, erect and paint structural metals called for in these Specifications or as shown on the plans. Structural metals will include rivet, welding, special and alloy steels, metallic electrodes, steel forging, and castings, and iron castings. This work will also include any incidental metal construction not otherwise provided for, all in accordance with these specifications, Drawings or as directed by the Engineer.

413.1.2 Drawings

The Contractor shall submit to the Engineer working Drawings for steel structures for approval prior to use in construction. Such working Drawings shall be submitted sufficiently in advance of the start of the related work to allow time for review by the Engineer and correction by the Contractor of the Drawings without delaying the work. Such time shall be proportional to the complexity of the work, but in no case shall such time be less than six (6) weeks.

The working Drawings shall show details of any permitted options proposed in the work, details for connections not dimensioned on the plans, the direction of rolling the plates where specific orientation is required, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout Drawing of the entire structure, the location of any temporary supports that are to be used and the vertical alignment of the girder at each stage of the erection. Substantiating camber calculations shall be submitted with the working Drawings.

413.1.3 Inspection

Structural steel will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least ten (10) days notice before commencing the fabrication of any structural steel.

The Contractor shall furnish to the Engineer a copy of all mill orders, certified mill test reports and a Certificate of Compliance for all structural steel to be used in the work other than steel which is to be used under the provisions in Item 413.2.6, "Unidentified Stock Material". Certified mill test reports for steels with specific impact values shall include, in addition to other test results, the results of Charpy V-notch impact tests. When fine grain steel is specified, the test report shall include the grain size. Copies of mill orders shall be furnished at the time, orders are placed with the manufacturer. Certified mill test reports and Certificates of Compliance shall be furnished prior to start of fabrication of material covered by these reports. The Certificates of Compliance shall be signed by the manufacturer and shall certify to the Engineer the specifications to which the material has been manufactured and tested, and that the material is in conformance with said specifications and test requirements.

Material to be used shall be made available to the Engineer so that the each piece can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where said material is stored or where work on said material is being performed.

413.1.4 Shipping, Handling and Storing Materials

Members weighing more than two and one half (2.5) metric tons shall have the weight marked thereon.

In handling and shipping of the steel work, every care shall be taken to avoid bending, scraping, or overstressing the pieces. All pieces bent or otherwise injured will be rejected.

The loading, transporting, and unloading of structural material shall be so conducted that the metal will be kept clean. Material to be stored shall be placed above the ground upon platforms, skids, or other supports, and shall be kept free from dirt, grease, and other foreign material and properly drained and protected from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.

413.1.5 Falsework

Falsework used for the erection of structural steel shall conform to the provisions in Item 402, "Falsework and Centering for Bridges", except that dead loads shall consist of the weight of the structural steel and any other portions of the structures which are supported by the falsework.

Falsework and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within fifteen (15) cms. of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable relative vertical movement between the edge of deck form and the adjacent steel girders.

Loads imposed on existing, new or partially completed structures by the Contractor's construction methods and equipment shall not exceed the load carrying capacity of the structure, or portions thereof, as determined by the Pakistan Code of Practice for Highway Bridges, 1967 or as specified by the Engineer.

413.1.6 Continuous Members

Unless otherwise noted on the plans, structural steel girders have been designed for continuity in supporting girder dead load. The Contractor may at his option erect the girders in such a manner that the girder continuity for dead load is or is not as assumed in design. Furnishing and erecting the girders shall be subject to the requirements in this Item.

If erection procedures are to be used which will provide the designed girder continuity for dead load, members with field joints shall be pre-assembled in a no-load condition in a horizontal or an upright positions.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the Contractor shall furnish to the Engineer for review a statement of steel erection procedures with calculations, in sufficient detail to substantiate that girder capacity and geometry will be correct.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the structure shall, after erection, have a load carrying capacity at least equal to the designed structure shown on the plans. The

Contractor may increase the cross-sectional area or change the steel grades to provide the specified load carrying capacity subject to approval by the Engineer. Any additional steel or higher strength steels required to accommodate the method of erection selected shall be considered to be made for the convenience of the Contractor and no additional payment will be made therefor.

413.2 MATERIAL REQUIREMENTS

413.2.1 Description

The various materials shall conform to the specifications of ASTM as listed in the following tabulation with certain modifications and additions as specified.

Table 413-1: ASTM Designation for Various Materials

Material	ASTM Designation
Structural Steel	A 36
High strength low alloy structural manganese vanadium steel.....	A 441
High strength low alloy columbium vanadium steel.....	A 572, Grade 50
High-yield strength, quenched and tempered alloy steel plate suitable for welding	A 514
High strength steel bolts, studs, and threaded rods for general applications.....	A 449
High strength structural steel bolts, nuts and washers.....	A 325
High strength low alloy structural steel	A 588
Bolts and nuts	A 307
Carbon steel for forging, pins and rollers.....	A 668, Class G
Alloy steel for forging	A 668, Class G
Pin nuts	A 36
Carbon-steel castings	A 27, Grade 65-35
Gray iron castings	A 48, Class 30B
Malleable iron castings	A 47, Grade 32510
Carbon steel structural tubing.....	A 500, Grade B or A 501
Steel pile (Hydrostatic testing will not apply) ..... Grade B; A 106, Grade B; or A 139, Grade B	A 53, Type E or S,
Stud Connectors ..... through 1020 either semi- or fully skilled.	A 108, grades 1010

Structural steel designed on the plans as high strength low alloy structural steel shall conform to the following:-

Thickness	Materials-ASTM Designation
0 to 2 cms	A 441; A 572, Grade 50; A 588
2 to 5 cms	A 572, Grade 50; A 588
5 to 10 cms	A 588

All structural steel conforming to ASTM Designations: A 36, A 441 and A 572 shall be other than rimmed or capped steel.

Coiled steel plate shall not be used for the fabrication of flanges, eyebars and hanger plates nor for flanges and eyebars.

All structural steel precut prior to arrival at the fabrication site shall be cut so that the plate orientation complies with the requirements of Item 413.3.3, "Orientation of Plates".

All structural steel plate used for the fabrication of tension flanges, eyebars and hanger plates and for splice plates of tension flanges and eyebars shall meet the longitudinal Charpy V-notch impact value requirements specified herein. Sampling procedures shall conform to the provisions in ASTM Designation; A 673. The H (Heat) frequency of testing shall be used for structural steels conforming to ASTM Designations: A 36, A 441, A 572 and A 588. The P (Piece) frequency of testing shall be used for structural steel conforming to ASTM Designation: A 514. Charpy V-notch impact values shall be determined in accordance with ASTM Designation: E 23.

Charpy V-notch (CVN) impact values shall conform to the following minimum values: (Note: all metric values in this test are rounded to closest decimal).

Table 413-2: Charpy V-notch (CVN) Impact Values

Material	Impact Value Ft.Lbs. at Temp. (Kg-m at Temp.)
A 36	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 441	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 572*	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 588* 2" and under in thickness ..... (50.8mm & under in thickness).....	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 588* Over 2" to 4" in thickness ..... (Over 50.8mm to 101.6mm in thickness)	20 at 40 deg. F. (2.77 at 4.45 deg. C)
A 514 2.1/2 & under in thickness ..... (63.5mm & under in thickness).....	25 at 0 deg. F. (3.46 at-17.8 deg. C)
A 514 Over 2.1/2" to 4" in thickness ..... (Over 63.5mm to 101.6mm in thickness)	35 at 0 deg. F. (4.84 at-17.8 deg.C)

*If the yield point of the material exceeds 65,000 psi (4569.5 Kg/Sq.cm), the temperature for the CVN impact value for acceptability shall be reduced to 15 deg. F. (-9.45 deg. C) for each increment of 10,000 psi (703 Kg/Sq.cm) above 65,000 psi (4569.5 Kg/Sq.cm).

Stud connectors shall be produced by cold heading, cold rolling or cold machining. Finished stud connectors shall be of uniform quality and free of injurious laps, fins, seams, cracks, twists, bends or other defects. Studs shall not have cracks or bursts deeper than one half (1/2) the thickness from the periphery of the head to the shaft. Tensile strength of stud connectors shall be determined by test of bar stock after drawing or of full diameter finished studs at the option of the Contractor. Strength requirements shall conform to the following:

Table 413-3: Tensile Strength Requirements for the Stud Connector

Tensile Strength	Elongation	Reduction of Area (Min.)
(Min.) 60,000 psi (4218 Kg/Sq.cm)	(Min.) 20% in 2 inches (50.8 mm)	50%

Stud connectors shall be furnished with arc shields (ferrules) of heat-resistant ceramic or other suitable material for welding.

413.2.2 Structural Steel

Unless otherwise specified or shown on the plans, all structural steel plates, shapes and bars shall conform to ASTM Designation: A 36.

At the option of the Contractor, girder flange plates shown on the plans may be increased in thickness, and may be increased in length provided that the change does not involve a decrease in detailed thickness of any portion of said plates. For continuous girders, increases in length of girder flange plates, which involve changes in locations of butt welds between different thickness of flange plates, shall be approved in writing by the Engineer prior to fabrication.

When stud type shear connectors longer than twenty (20) cms. are to be used, they may consist of two (2) or more shorter studs of the type shown on the plans connected together with full penetration welds.

Rolled shapes may be substituted for the welded sections, and welded sections may be substituted for the rolled shapes shown on the plans, provided that the shapes and sections to be substituted comply with the following provisions:

a) The depth, width and average thickness shall be at least equal to those for the shape or section shown on the plans.

b) For welded sections, the flanges shall be welded to the web with continuous fillet welds on each side of the web. All welding shall conform to the provisions in Item 413.2.7, "Welding".

c) The strength classification of the material shall not be reduced.

413.2.3 Castings

Steel, gray iron, and malleable iron castings shall be provided with adequate continuous fillets cast in place in all re-entrant angles. The radius of curvature of the exposed surface of a fillet shall define the size of the fillet. The size of fillets shall not be less than one-half (1/2) of the thickness of the thinnest adjoined member nor less than one and one quarter (1.25) cms.

The dimensions of the finished casting shall not be less than the specified. Castings shall not be more than seven and half (7.5) percent overweight. Large castings shall be suspended and hammered over their entire area. No cracks, flaws or other defects shall appear after such hammering.

413.2.4 Bearing Pads

a. Metal Bearing Devices

Unless otherwise directed by the Engineer, the materials for metal bearing shall conform to the following requirements:
AASHTO M 107 for bronze bearings.

AASHTO M 108 for rolled copper alloy bearings.
ASTM B 438 for sintered metal power bearings.
AASHTO M 160 for galvanized steel bearings.

b. Preformed Fabric Pads

The preformed fabric pads shall be composed of multiple layers of two hundred and seventy (270) gms/SM (8-ounce) cotton duck impregnated and bound with high-quality natural rubber, or of equivalent suitable materials compressed into resilient pads of uniform thickness. The number of ply shall be such as to produce the specified thickness, after compression and vulcanizing. The finished pads shall with-stand compression loads perpendicular to the plane of the laminations of not less than seven hundred (700) Kg/sq.cm without detrimental reduction in thickness or extrusion.

c. Elastomeric Bearing Pads

Elastomeric bearing pads shall conform to the requirements in Item 406.2.5, "Elastomeric Bearing Pads".

413.2.5 Asbestos Sheet Packing (Concrete Joints)

Asbestos sheet packing shall be approximately fifteen (15) mm thick unless otherwise shown on the plans, and shall be composed essentially of compressed white chrysotile asbestos fibres bound together with a synthetic rubber binder and fillers.

The deformation of the sheet packing under a load of three hundred and fifty (350) Kg/sq.cm shall be not more than fifteen (15) percent. When tested between planed steel plates under a load of fifty five (55) Kg/sq.cm, the sheet packing shall show a static coefficient of friction less than 0.4 after 1.00-1.25 cm. movements.

Where asbestos sheet packing is shown on the plans to be placed in joints in the concrete, the bottom layer of the packing shall be firmly attached to the concrete using water-proof cement.

413.2.6 Unidentified Stock Material

Unidentified stock material, consisting of material which cannot be identified with certified mill test reports, may be used subject to the requirements in this item.

When unidentified stock material is proposed for use the Engineer may, at his discretion, select random test specimens from each piece. The number of such test specimens shall be entirely at the discretion of the Engineer. Test specimens shall be cut and machined in accordance with ASTM requirements. Test specimens from unidentified stock material, including those required for retest, shall be furnished, machined and got tested by the Contractor from approved laboratory at his expense.

Fabrication shall not be commenced until the materials involved have been approved by the Engineer.

Not more than fourteen (14) metric tons of unidentified stock material may be used on one contract.

Unidentified stock material shall be segregated from all other materials to be used in the work.

413.2.7 Welding

Welding materials, welding, welder qualification, and inspection of welding shall conform to the requirements of the American Welding Society Structural Welding Code

or other accepted codes as shown on the plans or as approved by the Engineer. Correction of weld faults shall be carried out in the presence of the Engineer.

413.2.8 Galvanizing

When galvanizing is shown on the Drawings, such galvanizing of products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips three (3) mm thick or thicker, shall conform to the specifications of AASHTO M 111 (ASTM A 123), except that complete seal welding of tightly contacting surfaces of such products prior to galvanizing is required only where seal welding is shown on the plans. Except for pre-galvanized standard pipe, galvanizing of material three (3) mm thick or thicker shall be performed after fabrication into the largest practical sections.

Galvanizing will not be required for stainless steel, mono metal and similar corrosion resistant parts.

All welded areas shall be thoroughly cleaned prior to galvanizing to remove all slag and other material that would interfere with the adherence of the zinc. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating.

Components of bolted assemblies shall be galvanized separately before assembly. Galvanizing of tapped holes will not be required. Galvanized surfaces, which are specified to be painted, shall not be chemically treated after galvanizing and prior to cleaning and painting.

413.2.9 Cleaning

All steel works shall be blast cleaned after fabrication in accordance with the Drawings and to the satisfaction of the Engineer. Steel work which is to be in contact with concrete shall be, after fabrication, wire brushed and cleaned to remove all loose rust, dirt and grease.

413.2.10 Painting

a) Shop Coat (Prime Coat)

The shop or prime paint coat for metal structures including edges, nuts, bolts, etc. shall be a factory mixed red lead Ready-Mixed Paint, AASHTO M-72.

Red lead pigment in the dry form or as a paste in oil shall conform to ASTM D 83. The ninety seven (97) % grade shall be specified for dry pigment.

b) First Field Coat (2nd prime Coat)

The first field coat shall be a red lead paint as specified for the shop coat, tinted light brown as required with lamp black in an amount not to exceed 30 gms. perlitre of linseed oil.

c) Second Field Coat (Finish Coat)

The paint to be used for the second field coat shall be field mixed and conform, unless specified otherwise on the Drawings, to one of the following AASHTO Specifications:

Foliage Green Bridges Paint,	M 67
Black Bridge Paint,	M 68
Aluminum Paint (Paste-Mixing Vehicle)	M 69
White and Tinted Ready-Mixed Paint (Lead and Zinc Base),	M 70

Red Lead (Dry and Paste-in Oil),	M 71
Red Lead Ready-mixed Paint (Tinted with Lamp black as directed by the Engineer),	M 72

d) Number of Coats and Colour

Steel shall be painted with one shop or prime coat and with not less than two field coats. The colour shall be as specified or determined by the Engineer. Coats shall be different in colour to permit detection of incomplete application.

e) Weather Conditions

Paint shall not be applied when the steel is damp, the air is misty, or when in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.

f) Application

Painting shall be done in a neat manner and may be applied with hand brushes or by spraying (without the addition of a thinner). Aluminum paint shall preferably be applied by spraying. By either method the coating applied shall be smoothly and uniformly spread so that no excess paint will collect at any point.

g) Inaccessible Surfaces

All surfaces which will be inaccessible after fabrication or erection, with the exception of contact surfaces shall prior to assembly receive the full protective treatment specified for the component of the structure including any additional priming coat and finishing coats, which for accessible surfaces would be applied subsequent to erection.

h) Inspection of Cleaning and Painting

The cleaning and painting of all structural steel parts shall be subject to detailed inspection and approval of the Engineer. Contractor shall be responsible for all defects or faults and the correction thereof at his own expense during fabrication, erection or subsequently discovered before or during the Period of Maintenance.

413.3 CONSTRUCTION AND FABRICATION REQUIREMENTS

413.3.1 General

The Contractor shall submit as soon as possible to the Engineer for his prior approval, full details of their proposed fabrication and erection procedures together with details and calculations of any temporary works which the Contractor proposes to install for the purposes of erection of the structural steel work. Workmanship and finish shall be equal to the best general practice in modern bridge shops.

413.3.2 Straightening Material

Rolled material before being laid out or worked shall be straight. Subassemblies and completed members shall be straight before being incorporated into the work. If straightening is necessary, it shall be done by methods acceptable to the Engineer. Details for methods proposed for straightening shall be submitted in writing to the Engineer prior to their use. After straightening, evidence of fracture or other damage will be cause for rejection of the material.

413.3.3 Orientation of Plates

Steel plates for flanges, eyebars, hangar plates, and splice plates for flanges and eyebars shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile or compressive stress in the member.

413.3.4 Cutting with Torch

Torch cutting shall conform to the requirements for preparation of material to the American Welding Society's Structural Welding Code or equivalent.

413.3.5 Facing and Bearing Surfaces

Surface of bearing and base plates and other metal bearing surfaces that are to come into contact with each other or with ground concrete surfaces or with asbestos sheet packing shall be flat to within three tenths (0.3) cm. and to within one and six tenths (1.6) mm tolerance overall. Surface of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric bearing pads or Portland cement mortar shall be flat to within three (3) mm tolerance in thirty (30) cm and to within five (5) mm tolerance overall.

Steel slabs where not in contact with other metal bearing surfaces may be hot-straightened in lieu of machining at the option of the Contractor, provided the above tolerances are met.

413.3.6 Fitting of Stiffeners

Girder stiffeners designated on the Drawings as bearing stiffeners shall be welded in accordance with details shown on the Drawings. Where the end of a stiffener is shown as "Tight-fit" on the plans, the end of the plate shall be so fitted that it bears on the girder flange with at least point bearing. Local clearances between the end of the stiffener and the girder flange shall not exceed one and six tenths (1.6) mm. Except where stiffeners are cut back, local clearances between the end of the stiffener and the girder flange which are too great to be sealed by the paint film shall be caulked prior to painting.

413.3.7 Bent Plates

Cold-bent load-carrying rolled steel plates shall conform to the following:

a) They shall be so taken from the stock plates that the direction of bending will be at right angles to the direction of rolling.
b) The radius of bend, measured from the concave face of the metal shall be as specified in the Manual of Steel Construction published by the AISC or equivalent.
c) Before bending, the corners of the plate shall be rounded to a radius one and five tenths (1.5) mm throughout that portion of the plate at which the bending is to occur. If a shorter radius is essential, the plates shall be bent hot.

413.3.8 End Connection Angles

Floor beams, stringers and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angle shall not be less than that shown on the detailed Drawings.

413.3.9 Finished Members

Finished members shall be true to line and free from twists, bends and open joints.

413.3.10 Screw Threads

Screw threads shall make close fits in the nuts and shall be American Standard Form, except that for pin ends of diameters greater than 3.81 cm (1.1/2 inches) they shall be made with six (6) threads to 2.54 cms (1 inch).

413.3.11 Match - Marking

Connecting parts pre-assembled for the purpose of setting up for welding or for drilling or reaming holes for field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

413.3.12 Finish

Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately. All sharp corners and edges, and edges that are marred, cut or roughened in handling or erection shall be slightly rounded by grinding or other suitable means.

413.3.13 Bolted Connections

Bolted connections unless otherwise shown on the Drawings shall be made with high-strength steel bolts conforming to ASTM Designation A 325. All bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

Bolts may be tightened to the required tension by use of a calibrated manual torque wrench, the turn-of-nut method, or by tightening and using direct tension indicators. The torque value or the direct tension indicator gap needed to develop the bolt tension will be determined by the Engineer. Checking of bolt tension shall be done by the Contractor in the presence of the Engineer and in such a manner that the Engineer can read the torque wrench gauge or direct tension indicator during checking.

Nuts shall be located, wherever practicable, on the side of the member, which will not be visible from the traveled way. Nuts or bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete.

413.3.14 Bolt Holes

Bolt holes shall be either punched full size, drilled full size, sub-punched and reamed, or sub-drilled and reamed.

Attention is diverted to the provisions in Item 413.3.17, "Assembly", and details shown on the Drawings for connections where drilling or reaming is required after the joint is assembled.

The finished holes shall be cylindrical, perpendicular to the plane of the connection and shall not be more than one and half (1.5) mm larger than the nominal diameter of the bolt. Holes shall be clean cut, without torn or ragged edges. All burns, fins, sharp edges and hole irregularities which would prevent solid seating of the parts shall be removed.

All holes punched full size, sub-punched, or sub-drilled shall be located with sufficient accuracy so that after assembling (before any reaming is done) a cylindrical pin three (3.0) mm smaller in diameter than the nominal size of the punched, sub-punched, or sub-drilled hole may be passed through the hole without drifting in at least seventy five (75) percent of the holes for each connection. All holes shall pass a pin four and a half (4.5) mm smaller in diameter than the nominal size of the hole.

Mis-punched or mis-drilled holes shall not be corrected by welding unless approved by the Engineer.

Punching, drilling and reaming shall conform to the following:

a) Punching

Punching or sub-punching of structural steel conforming to ASTM Designation A 26 where the material is thicker than two and a quarter (2.25) cm. will not be permitted. Punching or sub punching of high-strength structural steel where the material is thicker than two (2.0) cm. will not be permitted.

Holes sub-punched for reaming shall be sub-punched decimal six five (0.65) cm less in diameter than that of the finished hole.

b) Drilling

Drilling full size shall be done with the parts assembled on to a steel template with hardened bushings or may be performed with gang drill equipment if approved by the Engineer. The Engineer may require a proof assembly to check the fit of major field connections.

Where bolt holes are sub-drilled for reaming, they shall be sub-drilled decimal six five (0.65) cm less in diameter than that of the finished hole.

Drilling through templates shall be performed only after the templates have been accurately placed and firmly clamped or bolted.

If members are drilled while assembled, the parts shall be held securely together while drilling is being done.

Stock drilling of plate parts with precision gang drills will be permitted if all parts are firmly clamed during drilling and if the drill bits remain perpendicular to the work during drilling operations.

c) Reaming

Reaming shall be done after the pieces forming a built-up member are assembled and are firmly bolted together so that the surfaces are in close contact or after templates are securely located over the member. The pieces shall be taken apart before bolting, if necessary, and shavings removed. If it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked in order that they may be reassembled in the same position. Reamed parts shall not be interchanged.

Reaming templates shall have hardened steel bushings and holes accurately dimensioned. Templates shall have reference lines, which will permit accurate location of the template on the member or members to be reamed. Templates used for reaming shall be properly located on the material and shall be firmly clamped or bolted in position. Templates used for the reaming of matching members, or the opposite faces of one member, shall be exact duplicates.

Holes through assembled material that are to be reamed shall not consist of both sub-punched or sub-drilled holes and holes punched or drilled full size.

413.3.15 Pin Connections

Pins shall be accurately turned to the dimensions shown on the plans and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finished cut.

Pins and rollers shall be forged and heat-treated in accordance with the designation shown on the plans.

If pins are larger than twenty three (23) cms.in diameter, a hole not less than four decimal seven five (4.75) cms. in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

Holes for pins shall be bored true to the specified diameter, smooth and straight, at right angels to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

Machined surfaces for pins and holes shall be coated with a rust inhibitor that can be easily removed.

The distance outside-to-outside of holes in tension members and inside-to-inside of holes in compression members shall not vary from that shown on the plans by more than decimal eight (0.8) mm.

The diameter of the holes for pins shall not exceed that of the pins by more than half (0.5) mm for pins thirteen (13) cm. or less in diameter, or decimal eight (0.8) mm. for larger pins.

Holes for pins in built-up members shall be bored after assembly of the member, or may be bored prior to assembly, provided procedures approved in advance by the Engineer are followed which result in such holes being positioned to the same degree of accuracy as would be obtained if the holes were bored after assembly.

Pin-connected hangar plates shall be bored in pairs or in stacks firmly bolted or clamped together so that each pair of hangar plates is matched. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pin nuts on pin connections shall be tightened and the threads burred at the face of the nuts with a pointed tool.

413.3.16 Anchor Bolts

No anchor bolts shall be cast in the concrete.

Anchor bolts shall be set in round holes drilled or cast in the masonry. The size and length of bolts shall be as indicated on the Plans.

Bolts shall be accurately positioned by means of templates set to correct location and alignment so as to ensure proper span lengths, and tops of bolts shall be carefully set to proper elevation. Unless otherwise noted, bolts shall be installed plumb or normal to the finished bearing surface of the masonry.

When anchor bolt holes are drilled, a template shall be used to locate the bolts accurately and permit reinforcing steel bars to be shifted clear of holes before pouring concrete to prevent cutting these bars during drilling. The drilling shall be done prior to the erection of structural steel.

Bolts set in holes drilled or cast in the masonry shall have the portion below the bridge seat swedged, and the drilled or cast holes shall have a diameter at least one 1 inch (25 mm) in excess of the diameter of the bolt.

Anchor bolts for steel stringers for all bridges (weathering steel and/or painted steel) shall be A-36 galvanized steel and shall not be painted. The nuts and washers used on anchor bolts shall also be galvanized and shall not be painted.

Holes cast in the masonry for swedged bolts shall be formed with removable round sleeves sealed at their lower ends, and they shall be completely removed after the hole is cast. During cold weather, effective methods shall be used to prevent the freezing of water in anchor bolt holes.

After anchor bolts are finally and correctly positioned, the holes around them shall be completely filled. No grouting of anchor bolts will be permitted until all structural steel is set in its final position. After the masonry plates or shoes are set, the space between the bolts and the round holes through fixed plates or shoes shall also be filled with the same material. Slotted holes in expansion devices shall remain unfilled to allow free movement.

Mortar used for grouting anchor bolts shall be composed in accordance with one of the following:

a) One part Portland Cement and one part mortar sand by dry loose volume.

b) Non-shrink grout shall be used when specified. The grout shall have a minimum compressive strength of 350 Kg/Sq.cm (5000 psi) in seven days when tested in accordance with AASHTO T 106 except that the cube moulds shall remain intact with a top firmly attached throughout the curing period. The non-shrink grout shall have a minimum expansion of 0.0 percent after seven days when tested in accordance with AASHTO T 160.

When air temperature is below four (4) degree C, the Contractor shall provide adequate cold weather protection to maintain a minimum air temperature of four (4) degree C around surface of mortar for a period of three days.

If anchor bolts are mortared in place during cold weather, the bolts and surrounding masonry shall be kept at a minimum temperature of four (4) degree C for a period of three days.

When mortar filling is used for bolts inserted in holes drilled or cast in the masonry, the holes shall first be checked for depth by inserting and withdrawing the bolts. They shall then be partially filled with mortar into which the bolts shall be forced by uniform pressure or light blows from a hammer (flogging and running will not be permitted) so that excess mortar is pushed out at the top of the hole. The excess mortar shall be removed and finished off flush with the top surfaces of the masonry, masonry plate or shoe as the case may be.

Bolts shall be set to project approximately half (0.5) inch (13 mm) above the nut and shall be threaded to approximately half (0.5) inch (13 mm) below the nut in its final position.

Nuts shall be drawn up tight except over the slotted holes of expansion devices in which case they shall be positioned half (0.5) inch (13 mm) clear of the moveable parts. All anchor bolt threads shall be burred with a sharp pointed tool at the top of the nut. When nuts are set half (0.5) inch (13 mm) clear of moveable parts, the bolt thread shall also be burred immediately under the nut to prevent it becoming tight against the moveable parts.

Rockers or expansion plates with slotted holes shall be set with the proper tilt or offset as determined by the temperature prevailing at the time and so that they will be in their midway position at twenty (20) degree C or as indicated on the Drawings.

413.3.17 Assembly and Erection Procedures

a) General

The Contractor shall submit as soon as possible to the Engineer for his prior approval full details of their proposed erection procedure together with details and calculations of any temporary works which the Contractor proposes to install for the purposes of the erection of the structural steel work.

b) Storage at Site and Handling

The structural steelwork after arrival on Site shall be laid out in the area allocated by the Contractor. It shall be unloaded by crane, or other appliance, and carefully stacked on timbers and subsequently handled for erection in such a manner that no distortion or damage is done to the various members. No steelwork shall be stored directly on the ground.

c) Erection Generally

The works on site shall comply with the requirements stated in these specifications and the Contractor shall be responsible for providing all materials, skilled and unskilled labour, plant, equipment, supervision and all other things necessary for the erection of the steelwork on the Site as specified in the Contract Documents and shown on the Drawings.

The Contractor shall ensure that suitable plant and equipment of adequate capacity is used on the Site.

d) Supervision

The erection of the steelwork shall be under the direct charge of a competent Supervisor who has had sound experience in the erection of structural steelwork and who shall work full time on the Site from start to completion of the work.

e) Security During Erection

During erection the work shall be securely bolted or otherwise fastened and where necessary temporarily braced, so as to make adequate provision for all erection stresses and conditions, including those due to the erection equipment and its operation.

Each part of the structure shall be aligned as soon as possible after it is erected. Members shall not be permanently connected until the structure has been sufficiently aligned, leveled, plumbed and temporarily connected to ensure that they will not be displaced during the erection or alignment of the remainder of the structure. All temporary bracing shall be left in position until such time as erection is sufficiently far advanced for it to be no longer required.

f) Temporary Connections

Connections for temporary bracing and additional holes, members or cleats used to facilitate handling or erection shall be provided in a manner, which does not weaken the permanent structure or impair its serviceability.

g) Erection Packs, Etc

The Contractor shall provide and shall be deemed to have included in his rates and prices for providing a suitable range of steel erection packs, shims and wedges to be used as necessary to ensure the accurate adjustment of line and level of the steelwork erected on Site and for the temporary works referred to in the previous sub-item.

h) Setting Out

The Contractor shall be responsible for the final positioning, leveling, plumbing and alignment of all steelwork and the accurate placing of every part of the steelwork in accordance with the Drawings and his own fabrication drawings.

No steelwork shall be finally concreted until the positioning, levels, plumbing and alignment of the steelwork (or part of the steelwork if agreed by the Engineer) has been finally checked by the Contractor.

i) Work on Site

All work on Site shall comply with the following:

1) The steelwork after erection and fixing complete shall comply with the following maximum permissible dimensional tolerances:

i) Departure from overall plan dimensions at any level ....ten (10) mm.

ii) Departure from theoretical centres of adjacent beams or girders in any floor or roof ....five (5) mm.

iii) Departure from the true alignment of any plate girder relative to the associated setting out geometry shown on the Drawing ... five (5) mm.

iv) Departure from the true vertical centre line or any girder throughout its length of height ....five (5) mm.

v) Departure from the specified level of the top of any beam ....five (5) mm.

j) Site Connections

The Contractor shall make all site connections in accordance with the details shown on the Contractor's detailed fabrication drawings, which shall comply with the requirements of these Specifications.

Drifting shall not be used to correct a bad alignment.

Any additional holes required in the steelwork (which must first be approved by the Engineer) shall be drilled on the Site. Burning holes in the steelwork will not be permitted.

k) Contact Surfaces

All steel to steel contact surfaces shall be thoroughly cleaned and painted with two coats of primer as described in clause No 413.2.10 in this Specification. The surfaces shall be brought together while the second coating is still tacky.

l) Site Welding

Site welding will only be permitted where shown on the Drawings and with prior consent of the Engineer.

m) Inspection of Site Works

All parts of the steel-work will be subject to inspection by the Engineer. The Contractor shall afford all facilities and assistance for inspection during the progress of the works.

The Contractor shall whenever possible, give the Engineer at least twenty four hours notice of when materials or parts of the steelwork will be ready for inspection.
Materials or workmanship or parts rejected shall be remedied or replaced by the Contractor without extra charge and without affecting the time for completion of the contract.

Inspection as aforesaid by the Engineer shall not absolve the Contractor from being responsible for any error or fault that may be discovered subsequently and for the final accuracy of the Works.

n) Painting after Erection

1) All paints shall be applied in accordance with the manufacturer's instructions and as specified under clause 413.2.10.

2) Damaged areas of paint-work shall be thoroughly scraped, wire-brushed and cleaned to remove all rust, dirt, grease and loose primer, back to sound paint.

All surfaces shall be thoroughly cleaned prior to further painting.

Damaged areas shall then be treated as described in the cleaning and painting section.

The second priming coat shall be allowed to dry for at least twenty-four hours before application of the finishing coat.

o) Inspection

1) The structural steelwork shall be subject to inspection by the Engineer. That inspection will as far as possible be carried out at the Contractor's workshops, but the Engineer may at his discretion defer inspection of any parts of the structural steelwork until after those parts have been delivered to the Site. The Contractor and his suppliers shall afford the requisite facilities at all reasonable times and at all places for inspection and testing to be carried out by the Engineer.

2) All parts of the Works done on the Site will be subject to inspection by the Engineer. The Contractor shall afford all facilities and assistance for inspection as aforesaid during the progress of the Site Works and until the completion of the contract.

3) Materials or workmanship or parts rejected on inspection as aforesaid shall be remedied or replaced by the Contractor without extra charge and without affecting the time for completion of the whole or any part of the Works.

413.4 MEASUREMENT AND PAYMENT

413.4.1 Measurement

The quantity to be paid for shall be the calculated theoretical number of kilograms of different shapes of members.

413.4.2 Payment

The pay item shall include fabrication, erection and protective coating (painting). The measurement shall be the total weight of the finished member comprising plates, rolled sections, shear connectors, stiffeners, cleats, packs, splice plates and all incidentals, necessary to complete the item, without allowance for tolerance for rolling margin and other permissible deviations from standard weights, and excluding the weights of welds, fillets, bolts, nuts, washers and protective coatings. No deductions shall be made for notches, holes and the like each less than 0.01 square meter measured in area.

Fabrication shall include:

a) Preparation and supply of shop drawings.

b) Examining and checking steel plates for segregation, laminations, cracks and surface flaws and carrying out any remedial measures required by the Engineer in respect of such defects.

c) Cutting, marking off, drilling, notching, machining, form fitting, edge preparation and cambering.

d) Welding, riveting, bolting as the case may be, assembling and pre-heating.

e) Bolts, nuts and washers required to fabricate the steelwork and to complete the erection and installation of steelwork on Site, together with spares and service bolts, drifts, draw-up cleats and the like.

f) Welding shear connectors to steel members either at the place of fabrication or on Site and preheating.

g) Approval testing of welders.

h) Production tests of welding during fabrication including non destructive testing.

I) Marking members for identification and delivery in matching sequence.

Permanent erection shall include:

a) Temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments.

b) Approval testing of welders.

c) Permanent bolted and welded connections required on Site including the provision of preheat and shelters for welding.

d) Production tests of Site welding including non-destructive testing.

Protective coating shall include:

a) Specimen panels of blast cleaning.

b) Paint samples and dispatching to testing authority.

c) Paint application procedure trials.

d) Testing.

e) Masking and other measures to protect adjacent untreated steelwork.

f) Joint fillers and sealing of bolted joints.

g) Preparing materials for application.

h) Preparation of surfaces and painting of steelwork at the place of fabrication and on Site.

I) Complying with any special requirements in respect of ambient conditions for the application of protective treatment and for intervals between successive operations and applications.

j) Strip coats.

Pay Item No.	**Description.**	**Unit of Measurement**
413 a	Structural Steelwork.	Kg.

SECTION 414 SUSPENSION BRIDGES

414.1 SCOPE

The Contractor shall furnish all plant, equipment materials and labour in performing all operations in connection with the construction of suspension bridges complete and in accordance with the Specifications, Drawings and or as required by the Engineer-in-Charge.

414.1.1 BRIDGE LAYOUT

The Contractor shall establish centre points of the two towers on the two banks of the rivers. The distance between the two points should be measured. It should be ensured that this distance corresponds with that shown on the drawings.
Similarly, the centre points of anchorage blocks for main cable and wind guys on the two banks shall be established. Further layout and construction can then be proceeded after approval of the Engineer.

414.1.2 CIVIL WORKS

The civil work as shown on the drawings and specified shall include, but not limited to the following:

i) The preliminary works.
ii) RCC Anchor Blocks for main cables and wind guys.
iii) The suspension towers complete with RCC foundations, main structure as shown on drawings. The foundation shall be RCC block foundation or on concrete piles as specified.
iv) The access roads and completion work.
The works shall be carried out according to the applicable provisions of various sections and other Technical Specifications as contained in various sections.

414.1.3 SUSPENSION BRIDGE STRUCTURE

414.1.3.1 MATERIAL REQUIREMENTS

i) Steel Wire Ropes (Cables)
Steel wire ropes shall be of diameter shown on drawings conforming with the requirements of ASTM A 603.
ii) The steel transom and runners for deck of bridge and the handrail shall be as specified and as shown on drawings, complying with the provisions of ASTM A-36. The clamps shall be as specified and shall be made of steel conforming to ASTM A-36 steel plates strips.
iii) The timber for wooden deck shall be as specified, complying with the provisions of Section 16 – Wood work.
iv) U Grip for rope shall conform to DIN 741.
v) Saddle Plate shall conform to DIN-GS-60/62
vi) The bolts, screws, nuts and washers shall conform with BS-916.
The steel parts where specified, shall be properly galvanized. The Contractor shall supply manufacturer's certificate along with test reports for conformance with Specifications of the materials for approval by the Engineer-in-Charge before use.

Specification for GI Steel Hemp Core is as under:

STEEL WIRE ROPE

ROPE WIRE AND TYPES OF WIRE ROPE-SPECIFICATION DATA

CAST STEEL, WIRE: To be of hard crucible steel with minimum tensile strength of 155 kg/mm^2, or 220 000 lbs./in ^{2}, and minimum elongation of 2½per cent in 254 mm or 10 inches.

PLOW STEEL WIRE: To be of hard crucible steel with minimum tensile strength of 183 kg/mm^2, or 260000 lbs./in^2 and minimum elongation of 2 ½ per cent in 254 mm, or 10 inches.

ANNEALED STEEL WIRE: To be of crucible cast steel, annealed, with minimum tensile strength of 77.4 kg/mm^2 of 110000 lbs./in^2.

TYPES OF WIRE ROPES OR CABLES (Construction):

Type A-6 stands with hemp core and 19 wire s to a strand (=6 by 19), or 6 strands with hemp core and 18 wires to a strand, with jute, cotton, or hemp center.

Type B.-6 strands with hemp core and 12 wires to a strand, with hemp center.

Type C.-6 strands with hemp core and 14 wires to a strand, with hemp or jute center.

Type AA. -6 strands with hemp core and 37 wires to a strand (=6 by 37), or 6 strands with hemp core and 36 wires to a strands, with jute, cotton, or hemp center.

TABLE 414-1 – Weight and Tensile Strength of Wire Rope.

Description	Diameter		Approximate Weight		Minimum Strength	
	mm	Inches	Kg/m	I.bs/lt.	kg	Pounds
Galvanized cast steel, Type A…….	9.5	3/2	0.31	0.21	3965	8740
	12.7	½	.55	.37	6910	15.230
	25.4	1	2.23	1.50	27650	60.960
	38.1	1 1/2	5.06	3.40	63485	139.960
Galvanized cast steel, Type AA……..	9.5	3/2	.33	.22	3840	8460
	12.7	½	.58	.39	7410	16330
	25.4	1	2.23	1.50	27650	60960
	38.1	1 1/2	5.28	3.55	59735	131690
Galvanized cast steel, type B……..	9.5	3/2	.25	.17	2995	6600
	12.7	½	.42	.28	5210	11500
	25.4	1	1.68	1.13	20890	46060
	38.1	1 1/2	3.94	2.65	47965	105740
Galvanized cast steel, type C……..	25.4	1	1.59	1.07	18825	41500
	41.3	1 5/8	4.35	2.92	51575	113700
Galvanized plow steel, type A……	9.5	3/8	.31	.21	4690	10340
	12.7	½	.55	.37	8165	18000
	25.4	1	2.23	1.50	32675	72040
	36.5	1 7/16	4.66	3.13	69140	152430
Galvanized plow steel, type AA…….	9.5	3/8	.33	.22	4540	10000
	12.7	½	.58	.39	8750	19300
	25.4	1	2.35	1.58	32250	71100
	41.3	1 1/2	6.18	4.15	83010	183000

414.1.3.2 STORAGE & HANDLING

i). Storage of Steel Parts
Following rules must be observed, while transporting and storing the steel parts to avoid any damage.

- Galvanized and non-galvanized steel parts must always be stored under a roof with adequate protection from rain, and they should not be in contact with the ground.
- Galvanized steel parts should not be transported or stored together with salt or acid.
- Steel parts should be stacked and stored element/component-wise by avoiding mixing up the different elements. This way, any element or component can be easily located during the erection of the bridge.

- All fixtures (nuts/bolts, washers, thimbles and bulldog grips) should be packed/marked and stored separately according to their sizes.
- Proper Inventory must be prepared on arrival of components and maintained, to show the consumption of all components, to make a claim in running invoices
- Steel parts, particularly suspenders and reinforcement bars, should not be bent during carriage and storage.

ii). Wire Rope (Cable) Transportation and Storing

It is vital to handle and transport the steel rope carefully in order to avoid causing any damage like kinks, splices and broken strands.

The pulling or dragging the cable along the road during transportation is not permitted. The steel rope should be unreeled straight without any kinks or bends. Before cutting the rope, ends should be secured by a binding-wire (seizing) to avoid loosening of the cable wires. The ropes when unreeled shall always be transported in straight position.

414.1.3.2 ERECTION OF BRIDGE

i. General

Before undertaking the bridge erection, the contractor shall submit for approval of the Engineer-in-Charge a detailed method statement stating the procedure that shall be followed for erection of bridge. Any deviations from the approved procedure shall be only with the prior approval of the Engineer-in-Charge. The approval of method by Engineer-in-Charge or described hereof shall not relieve the Contractor of his responsibility to complete the work in all respects as specified and as directed by the Engineer-in-Charge.

ii. Safety & Security

As soon as the anchor blocks and towers are completed, the bridge erection works can be started. The bridge erection and fitting works are somewhat risky, and require especially skilled labour who will not suffer from giddiness. Because of this somewhat risky work, the necessary statutory safety precautions should strictly be followed and the respective responsibilities should be clarified before starting the work.

iii. Hoisting of Main Cable

The Contractor shall pull the steel ropes across the river safely with the help of anylon rope or any other safe method proposed by him and approved by the Engineer-in-Charge. The ends of cables pulled across the river should be protected by attaching an empty airtight plastic jerry cane, to safe guard their sticking in stones and rocks lying on river bed. The main steel rope should be pulled over the saddle plates or cable runners, installed at top of the towers and fixed temporarily at the respective turnbuckle at the main cable anchors. The cover plate of the saddle should be kept loose during bridge erection time but should be tightened firmly after completion of operation.

iv. Sag setting

It is one of the most important tasks during the erection of the bridge. The cables over saddle or cable plates or cable runners are loose as stated above. With this arrangement, the main cables can slide over the saddles when the bridge is being erected. With a leveling instrument, the exact hoisting sag could be fixed in the following way:

- The elevation of the hoisting sag should be marked on both the towers with permanent paint. The hoisting sag is difference between the top of cable on two towers and top of specified dip at mid point.
- The leveling instrument should be setup on the tower foundation so that its line of sight matches with the mark on the tower across the river. Setting up the leveling instrument at the prescribed hoisting sag
- Alignment of total length of cable must be in one line from one anchor block to the one on other side of river etc.
- elevation has to be done by trial and error, and may require several attempts

- The Main Cables should be pulled until they reach a level of about 8 inches (20 cm) higher than the hoisting sag.
- The cables should be clamped around the thimbles at the cross bar of the Turnbuckle of the main cable anchorage. The crossbar should be in the middle position of the threaded anchor bars when clamping the main cables, secured with two nuts in the front and one in the back in the turnbuckle as shown on drawings.
- The Main Cables should be left in this “over pulled” position for at least 12 hours so that some relaxation can take place.
- The turnbuckles should be moved to achieve the exact sag setting. For compensating elongations due to change in air temperature, the hoisting sag is to be checked at different times of the day for necessary adjustments. It is advisable to adjust the final sag setting during the hot day after noon, when the cables have accumulated maximum heat, i.e., during maximum elongation condition.
- The hoisting sags of the two Main Cables must be identical at any point of time.
- The sags should be checked from time to time when the fitting works are going on. Different elongations may take place due to dissimilar hidden cable relaxations when the tension increases. The possible sag differences should be adjusted with the help of the turnbuckles at the main cable anchor so that the Main Cables are always parallel. The dead load sag should be compared with the pre-calculated values after installation.

v. Fitting Suspenders and Centre Row of Bridge Deck

Fitting the suspenders and walkway elements shall be carried out observing full safety and security arrangements as follows:-

- The suspender fitting work should start from both the towers and proceed towards the centre of the bridge. This procedure should be easier and more advantageous than starting the fitting work from the centre. However, in order to achieve a proper symmetry of the suspenders, the central suspenders must be fitted first.
- Due to inaccuracies, the remaining spacing at the centre of the bridge might be either too long or too short. To safeguards this, the required distances to the towers and the centre have to be rechecked after fitting 10 suspenders.
- For proceeding with further erection, all the suspenders should be laid in sequence on the ground. The deck material consisting of transoms, clamps hooks and bridge deck should be ready. Special and safe, fitter platforms should be made for working on main cables and bridge deck. In addition cablecars should be installed on the top of two main cables.
- The suspenders pair in the centre of bridge should be erected first after precisely determining their position. The deck at centre suspenders should also be erected.
- Thereafter the erection of suspenders should start simultaneously from the two towers.
- To ensure the exact location of suspenders, the gauge sticks should be used for checking the spacing between them. While the suspenders &transoms are being erected, the distance between tower and centre should be checked at suitable interval say after ten installations and inaccuracies rectified. The installation of bridge deck consisting of runners and wooden floor can then be proceeded.
- It should be ensured that all clamps which hold the suspenders and deck are tightened firmly.

vi). Fitting Wind Guys and Bracings.

- The contractor should submit the shop drawing giving the sizes and length of wind guy and wind ties.
- The Contractor shall provide suitable platforms, cable car for working as required.
- The wind guys shall be carried across the river and installed at turnbuckles of their anchors in the same manner as for main cable and

shall be given initial tension. The ties for wind guys shall be laid on the deck. The ties shall be fixed with transoms and wind guys using clamps and turn buckles, as shown on drawings at correct position. Final adjustment of wind ties shall be made by using the grips with transoms and also turn buckle. The wind guys should then be adjusted at the final tension using turn buckles. After the wind guys and ties are installed, it should be checked if all the cables are tight and balancely fixed.

vii). Finishing Erection Work

After all the erection is completed, the cover plates at the top of saddles of main hoisting cables shall be fixed in position.

The handrail as shown on drawings shall be installed.

The contractor shall submit a report in the form of check list for daily installation in accordance with the approved erection procedure.

Pay Item No.	Description	Unit of Measurement
414 a	Providing and fixing.	
	i. GI Steel (hemp core) ropes 1.5" dia	LM
	ii. GI Steel (hemp core) ropes 1.25" dia	LM
	iii. GI Steel (hemp core) ropes 1" dia	LM
	iv. GI Steel (hemp core) ropes 3/4" dia	LM
	v. GI Steel (hemp core) ropes 1/2" dia	LM
414 b i	Providing Main cable clam	NO
414 b ii	Providing Transom Clamp	NO
414 b iii	Providing Road Bearer Clamp	NO
414 b iv	Providing Wind Guy Clamp	NO
414c	Providing GI Steel U Grips	
	i. 1.5" dia	Kg
	ii. 1.25" dia	Kg
	iii. 1" dia	Kg
	iv. 3/4" dia	Kg
	v. 1/2" dia	Kg
14 d	Providing GI Steel Thimble plate	
	i. 1.5" dia	Kg
	ii. 1.25" dia	Kg
	iii. 1" dia	Kg
	iv. 3/4" dia	Kg
	v. 1/2" dia	Kg
414 e	Providing R.S. Joist transom of any size	Kg
414 f	Providing Coupling machine for Ropes	NO
	i. 1.5" dia	
	ii. 1.25" dia	
	iii. 1" dia	
	iv. 3/4" dia	
	v. 1/2" dia	
414 g	Providing Saddle plates of approved quality for Ropes	
	i. 3 to 6 ropes	NO
	ii. 6 to 10 ropes	NO
	iii. 10 to 14 ropes	NO
414 h	Providing Steel runner of any size	Kg
414 i	Supply steel Decking Plate (Chequered)	
	i. 1/8" thick	Kg
	ii. 2/8" thick	Kg
	iii. 3/8" thick	Kg
414 m i	Launching of Jeep-able Suspension Bridges, complete in all respect including all arrangements as per design and direction of the Engineer In-Charge	LM
414 m ii	Launching of Foot Suspension Bridges, complete in all respect including all arrangements as per design and direction of the Engineer In-Charge	LM
414 n i	Launching of Foot Suspension Bridges, complete in all respect including all arrangements as per design and	LM

	direction of the Engineer In-Charge	
414 n ii	De-launching of Foot Suspension Bridges, complete in all respect including all arrangements as per design and direction of the Engineer In-Charge.	LM

SECTION 415 SLIP FORM CONCRETE

415.1 DESCRIPTION

Slip form is moved in a continuous process. It is a method of vertically or horizontally extruding a concrete section and is suitable for construction of structures such as piers of bridges and medians. It is a self-contained formwork system and can require little crane time during construction.

This is a formwork system that can be used to form any regular shape of core. The formwork rises continuously, at a rate of about 300 mm per hour, supporting itself on the core and not relying on support or access from other parts of the structure or permanent works.

415.2 MATERIAL REQUIREMENTS

415.2.1 Concrete

Except for the careful control of slump, concrete mixes for slip-forming do not differ from concretes to be used for construction by other methods. A slump of 4 inches, plus or minus 1 inch is specified because it becomes hazardous to place concrete with lower slumps. In hot, dry climates or with certain types of aggregates and cement, higher slumps may be required. The use of vibration, retarders and workability agents is of course desirable but not for the purpose of reducing the slump below 3 inches or reducing the free water necessary for lubrication.

The concrete is placed in the forms in even layers of 6 to 8 inches, keeping the forms as nearly full as possible and spading or vibrating each layer as it is placed. It is highly recommended that concrete be placed alternately in clockwise and counterclockwise directions or that other placing sequences or systems be used to prevent repetitious loading and rotation of the structure as a whole. If the rate of slide is materially reduced, placing the concrete in thin layers of 2 to 3 inches will decrease the time between successive placements and prevent cold joints.

It is important to keep slip form decks as nearly broom clean as possible in order to prevent spillings of set concrete from falling into the forms. The decks must be scraped and swept into clean-out openings or chutes provided for this purpose.

Control of set, workability, moisture content and temperature of the concrete is of great importance in slip forming operations. Retarding admixtures may be necessary in hot weather or when slide rates must be reduced to accommodate placing of a large number of inserts, placing heavy reinforcing steel or other time consuming operations. Mild doses of retarding workability agents are usually used to delay the set and increase plasticity without adding water. The use of ice in lieu of part of the mixing water to reduce the rate of cement hydration is highly recommended and is more effective and less dangerous than retarders.

In cold weather, accelerators or high-early-strength cement are sometimes required to increase the rate of hydration, provide heat at a faster rate and reduce the setting time. Because of the danger of uneven rates of set in different parts of the slip form, the use of high-early-strength cement or accelerators can be dangerous and is recommended only in special situations. An increase in cement content will often solve cold weather problems most effectively.

415.3 CONSTRUCTION REQUIREMENTS

415.3.1 Propulsion

Usually, the rate of speed of the slip operation is controlled by the rate of set of the concrete and not by the capabilities of the jacking system. If the jacking rate is too

high, plastic concrete may fall out from under the form, but if too slow, bonding to the form may occur, tearing the concrete or binding the form in place. Faster rates of slide are required in hot, dry weather and slower rates in cold, wet weather.

As the jack rods must carry the vertical loads without buckling, lateral bracing is necessary wherever there is no concrete present to give the necessary lateral support. Accordingly, wherever there are openings or walls are discontinuous jack-rod bracing must be built in. Jacks may be set to miss such openings. When jack rods are suspended from a structure above the top of the slide, the jack rods are in tension, are better able to maintain the accuracy of plumb of the structure and require no lateral support.

Jack rods are usually spaced from 4 feet on centers upwards to almost any spacing, depending on the form design and jack capacity. Yokes are most often designed at 5- to 8-foot spacing, depending on the maximum allowable span of the wales, the curvature of the wall, structural configuration, distribution of loads and load equalization. Jacks are concentrated at corners, deck beams, concrete hoppers, bridge landings, and other heavily loaded locations. The proper layout of the jacking system greatly affects the success of the slipform operation.

Jacks are almost always connected to operate simultaneously from a central pressure or power source and climb a predetermined stroke distance such as 1 inch simultaneously every time the electrical or hydraulic system is activated. Although most jacks have excellent stroke accuracy, field conditions, mechanical imperfections, and load variations require continuous checking and adjustment of level as required. Self-leveling devices usually keep forms level automatically but the levels of jacks relative to one another can be adjusted by hand jacking or manipulating valves.

415.3.2 Working Deck

Work-deck sheathing and joists are usually designed for dead load plus a construction live load of 75 pounds per square foot or concentrated buggy wheel loads and other construction equipment loading, whichever is greater. Power buggies deliver such high lateral loadings to slipform decks that they must be used with caution if at all. Beams and trusses may be designed for a uniform live load of 40 to 50 pounds per square foot. If the deck is to be used as a form to place a slab at the end of the slide (for example, a roof), the deck must be designed to take the weight of the slab plus construction loads.

The slipform working deck performs the important function of holding all the formwork together so that the various components act as a unit. The deck must also be capable of maintaining the plan dimensions of the structure throughout the height of the slide. The distances between walls must be kept within tolerances, square corners must be securely held and circular arcs must remain circular. The well constructed deck tends to remain level, prevent projections of the structure from moving out of position, and keep straight lines straight. Horizontal bracing utilizing wood, steel rods, steel plating, trusses and combinations of these is necessary to accomplish these functions and also to resist wind loads.

415.3.3 Rate of Slide

The rate of slide is checked by plunging steel rods into the concrete and measuring the amount of hard concrete that is in the forms. A minimum of 12 inches and maximum of 30 inches is recommended. If there is less than 12 inches of hard concrete in the forms the slide speed must be reduced to allow the concrete to set further. If the amount of hard concrete exceeds 30 inches, the rate of slide must be increased to prevent binding of the forms.

The rate of slide can also be checked by standing on the scaffold below the forms and scratching the green concrete to see how hard it is as it comes out of the forms. This of course takes some experience.

415.3.4 Rebar Considerations

Reinforcing steel for slipform work is in some respects more difficult to place and inspect and therefore must be detailed in a manner different from conventional concrete construction. The vertical steel is located to miss the yokes and is held in place at the top by templates attached to the deck and moving with it. The templates are placed at heights of from 4 to 10 feet above the deck— the higher the better. The steel is lapped and tied to the rod below, the laps being staggered for structural reasons and to distribute the work load more evenly on the iron workers. Lengths of these vertical bars are usually limited to between 10 and 15 feet, depending on the size of the bars, to reduce the whip which may develop on a windy day if the bars project too far above the templates.

Horizontal steel must pass under the yoke beams as the work progresses, a level at a time, and must be threaded through the vertical steel and the jack rods. This requires good detailing to make sure that it is physically feasible to place them. It may be necessary to add a few inches to the length of horizontal bars to give the iron workers a reasonable tolerance in long continuous runs of steel. The vertical spacing of horizontal steel must be analyzed to obtain the most efficient placing in the field. Spacing of 10 to 12 inches work very well and are recommended. On the other hand, the larger diameter bars are heavy, rigid and harder to place, so that this must be balanced against the spacing, limiting the bars to 1 inch diameter and smaller if possible. As it is not always possible to maintain optimum size and spacing and furnish the required steel area, careful analysis and good judgment are necessary to come up with the most feasible solution for any specific project. Spacing down to 3 inches and even bundling of bars has been used. Rods up to Number 18 have been placed in slipforms. Good detailing will actually make placing easy. With the slipform deck as a work platform, the rebar men can operate safely, comfortably and efficiently right at “ground level.”

The lengths of horizontal bars are limited to 20 feet or less depending on the configuration of the particular structure. Bars longer than 20 feet are difficult to handle in the field unless expensive crane handling is provided. Hooked and bent bars are made shorter to facilitate placing.

Ties and stirrups must be detailed to provide for placing from the sides. Ninety- degree hooks are used in lieu of standard hooks as these hooks can be rotated into position about their axes. As they cannot be dropped in from the top, ties must be detailed as open pieces that can be placed from the sides of columns, pilasters or walls and lapped to fully meet code requirements. Interference with the yokes must be avoided.

Since large areas of reinforcing steel cannot be inspected at one time, and since concrete placing cannot be delayed, inspection of reinforcing steel in slipform work requires a systematic procedure. The rebars are continuously swallowed by the concrete as the forms rise at a rate of 8 to 12 inches an hour or more. It is therefore necessary that all horizontal steel be designed in horizontal layers; in other words, all horizontal steel should be at the same vertical spacing or at least in multiples of that spacing. This enables the rebar crew to place at one time a full set of steel as shown on the drawings.

The inspector then can check layer by layer to make sure that no bars are omitted or improperly placed. Light steel such as hairpins, ties and corner bars that might be easily omitted must be carefully checked. In order to ensure proper vertical spacing of the horizontal steel, positive provisions are required for marking each layer.

Some of the provisions available are as follows:

- Spaces are marked on vertical bars at several deck locations using tightly wound tying wire.

- Light angle irons are sometimes embedded in the concrete with holes to set the spacing. These angles are bolted together in sections as the slide progresses.

- Short bars which clear the yokes may be tied several courses ahead of the courses being placed as guides for the rest of the bars.

- Marking the ends of bars on the deck eliminates individual measurements each time a layer is placed and is a great help to both placing and inspection. These markers must be of a raised type such as double headed nails, V-notches, steel plates or wood blocks but must not be a tripping hazard to the men working on the deck.

There is little or no tying of steel in slipform work as the rebars may be placed directly on the concrete. Minor variation in spacing is usually not critical as long as the actual steel area provided is adequate and maximum allowable spacings are not exceeded. Tying must be provided as required to ensure proper clearance between the rebars and the forms.

415.3.5 Control of Tolerances

As with any other forming system, as the slide progresses there is a tendency for the forms to move out of line by translation, rotation, or a combination of both. Structures that are small in plan are more difficult to keep within tolerances but are also more readily brought back into proper alignment as they do not have the inertia of larger structures. Usually these movements are individually very small but they could total several inches out of plumb in a structure if corrections were not instituted. Careful surveillance of plumb deviations is necessary, and prompt but not hasty corrective action is in order. Since the forms are perpendicular to the deck any tilting of the deck will cause the structure to grow in the direction towards which the deck is tilted. It is therefore very important that the deck be level at all times unless a tilt is required for correction.

The forms must be strongly built and checked for level before the slide starts. During the slide, levels must be checked frequently to ensure that all jacks are operating within 1⁄2 to 3⁄4 inch of the correct elevation. Jacks that get too far ahead of their fellows are brought back into line by causing them to miss one climb. Jacks that lag behind may be manually brought up to proper level. In addition to the use of automatic leveling devices, frequent inspection is required to double-check the operation of the leveling system.

Frequently hack saw marks are cut into the jack rods at 12-inch intervals and the jacks are checked against these marks. It is necessary of course to make sure that the saw cuts are accurately made. Water- level systems are also effective. With these a central tank is filled with water and plastic hose is run to the various jacking points where a vertical tube indicates the water level at each jack. Unless all air bubbles are expelled from the system, false readings will be obtained. In addition, periodic readings must be made to determine deviation from plumb of the various points of the structure. These readings may be required as frequently as every three hours for structures requiring close tolerances and those with a plan that is particularly subject to drifting. Readings at twelve to twenty-four hours are usually adequate for most slipform construction having a stable plan and being required to meet the ACI tolerance of 1 inch in 50 feet of height.

Vertical plumb readings must be made in two directions at right angles to each other in order to detect movement in any direction. Targets must be placed in several strategic locations around the structure on the forms themselves and must be clearly marked and self reading. Once the form has been raised a foot or so, a transit or a carpenter's level is used to transfer the target line down to a chisel-cut in the concrete which can be used as a backsight for subsequent readings. To check the plumb a transit shot is taken of the form target and checked against the chisel-cut in the concrete. Plunging the transit for a second shot will eliminate any transit maladjustments.

The optical plumb is essentially a weighted telescope which hangs freely like a plumb bob in a pivoted collar and transfers a plumb line of sight to a target box set at the base of the slide. Deviation from plumb is checked by direct reading through the telescope. A target box and mounting collar is required at every point to be checked, but one or two optical plumb telescopes can be moved to cover all positions. At great heights the optical plumb becomes difficult to use because of wind and vibration.

Today, laser beam instruments are gaining popularity for monitoring tolerances in slip form work.

Tolerances of 1 inch per 50 feet of structure and 2 inches for the full height of the structure (without regard to height) are reasonable. Nevertheless, the designer must remember that this tolerance is a minimum and that greater tolerances will save some headaches and result in maximum economy when conditions permit. Tolerances within 1⁄2 inch have been almost consistently achieved when necessary in full cores to 400 feet; good forms and procedures were of course necessary to achieve this. To expect such tolerance and include it in specifications is ordinarily excessive and unreasonable but all forms and procedures should be designed to achieve it.

415.3.6 Finishing and Curing

Finishing provides no problems in sliding form construction because the concrete emerges from under the form in excellent condition for a float and brush finish. The finishing is performed comfortably from the hanging scaffold. The absence of joints and tie holes results in a finish that is very durable in any climate.

Curing is usually achieved by use of membrane curing compounds applied directly from the finishers' scaffold. Water curing using water lines hung from the forms is sometimes used but is subject to many problems. If water curing is used, fog type nozzles are recommended to prevent erosion or discoloration of the concrete.

415.3.7 Safety

- Working platforms, guard rails, ladders and wind shields are normally built into the completed system.
- Reduced use of scaffolding and temporary work platforms results in a less congested construction site.
- The completed formwork assembly is robust and provides a stable working platform.
- The strength of the concrete in the wall below must be closely controlled to achieve stability during operation.
- The uniform and continuous nature of the work ensures that site operatives can quickly become familiar with health and safety aspects of their job. Formwork suppliers provide materials and resources to help train the labour force.
- High levels of planning and control mean that health and safety are normally addressed from the beginning of the work.

415.4 MEASUREMENT AND PAYMENT

415.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters of concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of openings, pipes and conduits, etc., in case where their cross-sectional areas exceed 500 square centimeters.

The volume involved in fillets, scorings, or chamfers ten square centimeters in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for.

415.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below that as per shown in the Bill of Quantities which prices and payment shall be full compensation also for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

Pay Item No.	Description.	Unit of Measurement
415a	Concrete Class ..... (By Slip forming)	CM

SECTION 416 SELF COMPACTING CONCRETE (SCC)

416.1 DESCRIPTION

Self Compacting Concrete, also known as Self Consolidating Concrete (SCC), is a highly flow able, non-segregating and highly stable and durable concrete that can be spread and placed into any shape of formwork and encapsulate reinforcement without requiring any mechanical consolidation.

Self Compacting Concrete shall have following properties
:

1. Easily fill restricted section and hard to reach places.
2. Ease of placement around congested reinforcement.
3. No need of mechanical vibration to achieve compaction.
4. Better finishing surface devoid of honey combing
5. Improved pumpability and handling.
6. Self levelling characteristics.
7. Homogeneity during and after placement.

416.2 MATERIAL REQUIREMENTS

All materials for Self Compacting Concrete shall generally conform to the requirements of Item 401 “Concrete” of this specification, in addition to the following mandatory requirements.

TABLE 416-1: MATERIALS SPECIFICATIONS

Material	Classification	Specification
Portland cement	Type I, II, III, or V	ASTM C 150
Blended hydraulic cement	Type IS, IP, I (SM), or I (PM)	ASTM C 595
Hydraulic cement	Type GU, HE, HS, MS, or MH	ASTM C 1157
Fly ash	Class C or F	ASTM C 618
Ground-granulated blast-furnace slag	Grade 100 or 120	ASTM C 989
Natural pozzolans	Class N	ASTM C 618
Silica fume (slurry or densified)		ASTM C 1240
Coarse aggregate	No. 67, 7, 8, or 89	ASTM C 33
Fine aggregate		ASTM C 33
Chemical admixtures	Types A to G	ASTM C 494
Super-plasticizers	Type I & II	ASTM C 1017
Viscosity Modifying Agents	cellulose-ethers and biopolymers (xanthan, welan, and diutan gums)	ENC 180VMA R13
Air-entraining admixtures		ASTM C 260
Water		ASTM C 1602

416.2.1 Cement

Selection of cement for Self Compacting Concrete shall not be based only on mortar-cube tests alone but shall also include tests of flowabilty and comparative strengths of concrete at 28 days. Cement that yields the highest concrete compressive strength at designated testing age and desired flowability shall be preferable.

416.2.2 Coarse Aggregates

In Self Compacting Concrete, careful attention shall be given to aggregate size, shape, surface texture, mineralogy, and cleanness. To find the optimum size of aggregate which will give maximum concrete strength, trial batches shall be made with 19 mm (3/4 inch) and smaller coarse aggregates gradations and varying cement contents. The gradations for various sizes of aggregate shall be as follows:

TABLE 416-2: GRADING REQUIREMENTS FOR COARSE AGGREGATES

ASTM Size Number	Nominal Size	Amount Finer than Each Sieve (Square Opening), Mass Percent							
		25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 µm
67	19.0 to 4.75 mm	100	90 to 100	…	20 to 55	0 to 10	0 to 5	…	…
7	12.5 to 4.75 mm	...	100	90 to 100	40 to 70	0 to 15	0 to 5	…	…
8	9.5 to 2.36 mm	...	…	100	85 to 100	10 to 30	0 to 10	0 to 5	…
89	9.5 to 1.18 mm	...	…	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5

Coarse aggregates used in SCC shall be clean, that is, free from detrimental coatings of dust and clay. For this purpose aggregates shall be washed at production quarry before delivery to the batching plant. Combining single sizes of aggregates to produce the required grading shall be adopted for close control and reduced variability in the concrete.

416.2.3 Fine Aggregates

Sand with a fineness modulus (FM) between 2.8 and 3.2 shall be used in preparation of Self Compacting Concrete. FM shall not vary by more than 0.10 from the Mix Design FM selected, for the duration of the project. Sand Equivalent value of aggregates shall not be less than 85. Gradation of Fine aggregate shall be as follows:

TABLE 416-3: GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight.
3/8 inch (9.5mm)	100
No. 4 (4.75mm)	95-100
No. 8 (2.36mm)	80-100
No. 16 (1.18mm)	50-85
No. 30 (600□m)	25-60
No. 50 (300□m)	5-30
No. 100 (150□m)	0-10
No. 200 (75□m)	0

Fine and coarse aggregates shall be free from any coatings that could impair paste aggregate bonding. Necessary precautions shall be taken by the contractor at the concrete production facility to keep the aggregates clean and prevent contamination.

416.2.4 Chemical Admixtures

The use of chemical admixtures such as water reducers, retarders, high-range water reducers (HRWR) or superplasticizers shall be as per mix design. The chemical admixtures shall be compatible with cement and supplementary cementing materials.

Air entraining admixtures shall only be used in SCC when specified in the contract documents and approved by the Engineer in writing.

The use of Viscosity Modifying Agents (VMAs) shall be as per mix design. VMAs shall have the capability to minimize the movement of water and fines away from the bulk concrete and maintain a homogeneous composition in addition to controlling excessive bleeding, segregation, honeycomb, laitance, settlement, and plastic cracking.

416.2.5 Supplementary Cementing Material

Fly Ash, Silica Fume, Ground-granulated blast furnace slag (GGBFS) or Stone Dust (passing 0.125mm sieve) shall be used in the production of SCC as per approved mix design.

Blended cements containing fly ash, silica fume, slag, or calcined clay can be used to make SCC with or without the addition of supplementary cementing materials.

416.2.6 Mix Design

The trial mixture approach shall be used for selecting proportions for SCC. As a guideline following volumetric proportions can be used as starting point to prepare final mix design

Constituent	SCC
Air Content	2%
Cement + Powder	19%
Sand	27%
Coarse Agg.	34%
Water	18%

Notes:
1. Air Content can be increased up to 4% for Air Entrained Concrete.
2. Cement + Powder means cement and supplementary cementing material as defined in section 416.2.5. Powder content shall not be more than 35% of cement content.
3. VMA dosage shall not be more than 0.1% of weight of cement + powder.

416.2.6.1 Mix Design Procedure

Mix Design shall be carried out as per ACI 237R-07 (or later).

Mix Design Submittal Requirements.

Unless otherwise specified, concrete mixture proportions shall be submitted for approval at least 60 days before production.

Each concrete mixture proportion submittal shall include, as a minimum, the following information:

- Project identification;
- Name and address of concrete supplier and concrete production facility;
- Date mixture prepared;
- Date of report;

- Mixture design designation;
- Specified compressive strength of concrete and other specified properties at the required age;
- Concrete mixture proportions, based on the saturated surface-dry weights of the coarse and fine aggregates;
- Test results showing material properties of fine and coarse aggregates, including gradations, relative density (specific gravity), absorption, acceptance criteria, and compliance;
- Names and locations of all material sources;
- Certificates of compliance for cement, supplementary cementitious materials, aggregates and admixtures, accompanied by test reports showing test results, acceptance criteria, and compliance;
- Statement of methods for site adjustments using admixtures, if proposed;
- Documentation demonstrating that the proposed mixture proportions produce concrete meeting the specified properties.

416.2.6.2 Mixture Proportions, Trial and Field Batches

The proportioning of mixtures and requirements for trial batches of concrete shall be carried out to fulfill following requirements.

Trial batch tests: Contractor shall submit trial batch test results including test dates for each mixture proposed for use on the project.

Field verification tests: Contractor shall submit field verification test results including test dates for each mixture proposed for use on the project.

Mixture proportions: Concrete mixtures shall be proportioned to attain the properties at the acceptance ages specified in the contract documents. The contractor shall submit the trial batch test results including test dates to the Engineer for review and acceptance.

Field verification tests: Field verification of the compressive strength and other properties specified in the contract documents shall be performed before the start of construction.

Laboratory trial mixtures: All trial mixtures shall be prepared and tested by an approved laboratory.

Field verification: Field verification tests shall simulate the same mixing, transportation, and placing procedures proposed for use on the project. Field verification tests shall be performed in accordance with applicable ASTM standards. The batch sizes for field verification tests shall be representative of the batch sizes proposed for use on the project. For each field verification batch to be evaluated, and for each test age, a minimum of three specimens for each specified property shall be tested, unless a greater number of specimens are required for a specific test. Testing of fewer than three specimens for each specified property shall require prior approval by the Engineer.

416.3 CONSTRUCTION REQUIREMENTS

All requirements of Item 401 shall be followed in addition to the following specific requirements for SCC.

416.3.1 Mixing

Batching and mixing sequences shall be optimized during the trial mix phase so that concrete does not become sticky or “balling” of mix does not occur during transport.

Where transit truck mixing is unavoidable, the concrete load shall be reduced to 90% of the rated capacity of the trucks.

Unless otherwise specified, the minimum batch size shall be three (3) cubic meters, unless prior approval for a smaller batch size is obtained from the Engineer.

If SCC is to be procured from premix concrete producers, prequalification of concrete suppliers shall be carried out. Ready-mix concrete shall comply with requirements of ASTM C-94. In a prequalification procedure, one or more loads of the proposed mixture shall be cast into a trial mock-up. The fresh concrete shall be tested for slump, air content, temperature, and density. Cores shall be taken from the hardened concrete to carry out further tests e.g. compressive strength, modulus of elasticity etc. as per design requirements.

Following requirements shall be adhered to in preparation of Self Compacting Concrete.

Mixing: All batches shall be mixed a minimum of 100 revolutions, or for a period sufficient to comply with the concrete uniformity requirements of ASTM C 94, whichever is greater.

Washing trucks: Trucks shall be completely washed out and emptied of all wash water before receiving a batch of Self Compacting Concrete.

Automatic measurement of moisture content: The concrete production facility shall be equipped with a calibrated automated device to measure the moisture content of the fine aggregates and automatically adjust the amount of batch water required. The moisture measurement device shall be calibrated at least every 28 days during the production of Self Compacting Concrete.

Measuring moisture content during production: Before the start of the production each day, the moisture content of the coarse aggregates shall be determined in accordance with ASTM C 566. Moisture content measurements shall also be made at any other time during production when it is believed the moisture content of the coarse aggregates has changed by more than 1%.

Moisture content records: A record of aggregate moisture content testing shall be available for inspection at the concrete production facility at all times during batching.

Rinsing trucks: Rinsing of the delivery truck collection hoppers and internal drum components after batching shall not be permitted, except under the direct onsite supervision of trained quality control or plant supervisory personnel. The amount of water used for rinsing the truck collection hoppers and internal drum components, after batching and before the truck leaves the plant, shall be kept to a minimum, and shall not exceed eleven (11) liters of water per batch, and shall be considered as part of total water in the load.

Batch tickets: Unless otherwise specified, each batch ticket shall include, as a minimum, the following information:

- Name of ready-mix company and batch plant, or batch plant number;
- Serial number of ticket;
- Date;
- Truck number;
- Name of purchaser;
- Specific designation of job (name and location);
- Specific class or designation of the concrete using the same nomenclature as employed in project specifications;
- Amount of concrete in cubic yards (cubic meters);
- Time loaded or time of first mixing of cement and aggregates;
- Amount of water added by receiver of concrete and their initials;
- Total amount of water in the load as batched.

Additional information for certification purposes as designated by the Engineer and required by the job specifications shall be furnished. This information may include:

- Reading of revolution counter at the first addition of water;
- Type, brand, and amount of cement;
- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans;
- Grade, brand, and amount of ground-granulated blast furnace slag;
- Type, brand, and amount of silica fume;
- Type, brand, and amount of admixtures;
- Type, brand, and amount of fiber reinforcement;
- Source and amount of each metered or weighed water;
- Information necessary to calculate the total mixing water. Total mixing water includes free water on aggregates, batch water (metered or weighed) including ice batched at the plant, and water added by the truck operator from the mixer tank;
- Maximum size of aggregates;
- Mass (amount) of fine and coarse aggregates;
- Ingredients certified as being previously approved; and
- Signature or initials of producer's representative.

Delivery tickets: Delivery tickets shall be filled out completely and shall not be surrendered by drivers until completion of discharge of concrete except for review by the inspector.

Addition of water: The addition of water to Self Compacting Concrete after the concrete has been batched shall not be permitted, unless the addition of water is carried out in strict accordance with procedures preapproved by the licensed design professional.

Mixing time: Unless otherwise specified, discharge of the concrete shall be completed within 1-1/2 hours, or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. These limitations are permitted to be waived by the Engineer if the concrete is of such slump flow that after the 1-1/2 hour time or 300-revolution limit has been reached it can be placed and consolidated, without the addition of water to the batch. In hot weather or under conditions contributing to quick stiffening, the time of 1-1/2 hours may be reduced by the Engineer.

416.3.2 Placing, Consolidation and Curing

Close liaison between the contractor and the concrete producer shall be ensured to allow concrete to be discharged rapidly after arrival at the jobsite. Final adjustment of the concrete shall be supervised by the concrete producer's technicians at the site, by a concrete laboratory, or by a consultant familiar with the performance and use of Self Compacting Concrete.

Self Compacting Concrete shall fully consolidate under its own weight without any need for mechanical vibration.

Delays in delivery and placing must be eliminated; sometimes it may be necessary to reduce batch sizes if placing procedures are slower than anticipated. Rigid surveillance must be exercised at the jobsite to prevent any addition of re-tempering water. Increases in workability should only be achieved by the addition of a super-plasticizer (HRWR). This should be done by a qualified technician. On-site addition of a high-range water-reducing admixture of the same brand and type used at the concrete production facility shall be permitted at the discretion of the Engineer. A procedure shall be submitted by the contractor for on-site addition of HRWR admixture and approved by the Engineer before the start of construction. A record of job-site-added HRWR admixture shall be maintained and shall be available at the project site at all times. A site-added HRWR admixture shall be introduced to the batch by means of a pipe or

wand capable of placing the product near the center of the mixing drum, and using an automated admixture metering device. The batch shall then be remixed until uniform. An admixture shall be introduced at the site only in accordance with the recommendations of the admixture manufacturer. If a batch of concrete becomes segregated in the opinion of the Engineer or his representative at site, as a result of on-site addition of excessive high-range water-reducing admixture, that batch shall be rejected.

Appropriate curing methods as per ACI-308 for various structural elements shall be selected in advance to ensure proper curing of SCC.

Immediate application of curing compound on placed SCC shall not be allowed although evaporation retardants may be applied immediately after finishing. Wet curing shall be carried out for SCC for the first 7 days followed by application of two coats of curing compound. Wet curing shall be continuous and no part of concrete shall be allowed to be left for even a short time dry during wet curing period.

Following additional curing considerations shall be adopted for SCC. Where silica fume is used in the mixture “fog curing” or evaporation retarders shall be applied to the concrete immediately after the surface has been struck off.

Water curing of vertical members is usually impractical, and other curing methods shall be employed, such as leaving the forms in place for 2 to 3 days.

Hot weather concreting:
Unless otherwise specified, Self Compacting Concrete shall be placed in hot weather as defined in Item 401.

Cold weather concreting:
Unless otherwise specified, Self Compacting Concrete shall be placed in cold weather as defined in Item 401.

Following additional placing requirements shall be met by the contractor at the job site:

Placing equipment: Equipment for placing the concrete shall have adequate capacity to perform its intended function. Stand-by equipment shall be available in the event of an equipment breakdown.

Depositing concrete: Concrete shall be deposited at or as close as possible to its final position in the structure. Buggies, chutes, buckets, hoppers, or other means shall be permitted to move the concrete as required.

Concrete of different strengths: In applications where concrete with two different strengths are being placed against one another, the higher-strength concrete shall be placed before the lower-strength concrete, without formation of a cold joint.

416.3.3 QUALITY CONTROL

Contractor shall maintain independent Quality Assurance (QA) and Quality Control (QC) teams for SCC project who shall monitor all aspects of concrete production, mixing, placing and curing etc. The on-site material testing laboratory shall comply with ASTM C-1077

Tests on concrete shall be made in strict accordance with standard procedures.

Testing machines shall be of approved make and shall be certified to test Self Compacting Concrete.

416.3.3.1 Concrete Plant

Concrete Batching Plants used to produce Self Compacting Concrete shall be inspected regularly and certified to comply with the Check List requirements of the NRMCA-USA "Certification of Ready Mixed Concrete Production Facilities". QA/QC of concrete plant shall be carried out continuously until consistently acceptable batching is achieved. Thereafter, spot checking the plant shall be done unless the complexities of the project demand full-time monitoring. Full-time inspection shall be carried out at the batching plant for SCC.

QA/QC shall be carried out to ensure that the facilities, moisture meters, scales, and mixers (central or truck, or both) meet the project specification requirements and that materials and procedures are as established in the planning stages. QA/QC shall also be carried out regarding batching Self Compacting Concrete, such as using proper sequencing of ingredients, especially when pozzolans or ground slag are used. Scales, flow meters, and dispensers shall be checked monthly for accuracy, and shall be calibrated every six months. Moisture meters shall be checked daily. These checks and calibrations shall be documented. Plants that produce Self Compacting Concrete shall have printed records for all materials batched.

The QC or QA inspector shall be present at the batching console during batching and shall verify that the accepted types and amounts of materials are batched. Site tolerances and batch weights shall fall within the allowable tolerances as shown in Table 414-6.

TABLE 416-4: SITE TOLERANCES

Sr. No.	Description	Tolerance
1 a.	Specified slump flow	±25 mm
2.	Air Entrainment	±1.5 %
3 a.	Cement	±1.0 %
b.	Cement + Supplementary Cementitious Material	±1.0 %
4 a.	Individual size aggregate weight	±2.0 %
b.	Cumulative aggregate weight	±1.0 %
5.	Chemical Admixtures	±3.0 %
6 a.	Compressive strength test (average of three cylinders)	≥ specified fc'
b.	Compressive strength test (any individual test from 6a)	≥ (fc'-500) psi

When not witnessing the entire batching operation, QA/QC personnel shall perform or witness the following tests at least once daily (or once per eight-hour shift):

- Moisture content of fine and coarse aggregates in accordance with ASTM C 566.
- Aggregate gradations (fine and coarse) in accordance with ASTM C 136.
- Material finer than the 75-µm (No. 200) sieve in accordance with ASTM C 117.

Moisture content tests shall be repeated after rain and the other tests shall be repeated after deliveries of new batches of materials.

Substitutions of chemical admixtures shall not be allowed without the prior approval of the Engineer. Reference samples of cementitious materials shall be taken at least once

per day or per shipment for tests later on to investigate low strengths or other deficiencies.

Sources of additional mixture water such as “wash water” or any “left-over” concrete remaining in the truck drum prior to batching shall be identified. These shall be emptied from the truck prior to batching.

416.3.3.2 Delivery

Truck mixers used to transport Self Compacting Concrete shall be inspected regularly and certified to comply with the Check List requirements of the NRMCA-USA “Certification of Ready Mixed Concrete Production Facilities”. Truck mixers shall be equipped with a drum revolution counter, and their fins shall comply with NRMCA criteria.

The concrete truck driver shall provide a delivery ticket that contains the complete information specified in item 416.3.1. Every ticket shall be reviewed by the inspector prior to discharge of concrete.

If the batch is redosed at site, the amount of admixture added to the truck with a calibrated delivery system shall be recorded and the truck drum shall be turned at least an additional 30 revolutions at mixing speed. Therefore, the delivery ticket shall also provide a space for recording the following information:

- Water or admixtures added by authorized personnel at the job site.
- Approximate quantity of concrete in truck when additional water or admixture is added.
- Number of drum revolutions at mixing speed after the addition of water or admixture.

Addition of water at the job site shall be permitted only after prior written permission of the Engineer and provided that the maximum specified water-cementitious materials ratio is not exceeded.

416.3.3.3 Placing

Preparations at the project site shall be completed prior to delivery of the first truck load of concrete. QA/QC personnel shall verify that forms, reinforcing steel, and embedded items are ready and that the placing equipment are in working order prior to the contractor placing concrete.

Forming of cold joints between successive loads or between different types of concretes shall not be allowed.

416.3.3.4 Curing

QA/QC personnel shall verify that the accepted methods of curing are properly employed in the work.

The QA/QC inspector shall monitor and record ambient temperatures and temperatures at the surface and center of large concrete components so that the design/construction team can effectively make any adjustments, such as changes in mixture proportions or the use of insulating forms, during the course of the project. Concrete delivered at temperatures exceeding specification limits shall be rejected, unless alternative procedures have been approved by the Engineer. The inspector shall monitor that curing procedures are according to project specifications, particularly those at early ages to control the formation of plastic shrinkage cracks.

416.3.3.5 Testing

Slump Flow Test, Visual Stability Index test and T_{50} test shall be carried out as per ASTM C-1611. The value of slump flow can range from 450mm to 760mm. The lower values being suitable when placement of SCC is required in open, less congested areas (e.g. floors/slabs), while higher values are suitable for highly restricted and congested areas (e.g. slender columns and walls).

Other tests include J-Ring test, L-Box test, Column Segregation test (ASTM C-1610), V-Funnel test, Fill Box test, or any other test as per directions of the Engineer. Following table gives indicative range of test results for various tests.

Sr. No.	Property	Range
1.	Slump Flow Diameter	450-760 mm
2.	Visual Stability Index	0 or 1
3.	T_{50cm}	2-5 sec
4.	Column Segregation Test	$\leq$ 10%
5.	V-funnel	6-12 sec
6.	J-Ring	12 to 25mm
7.	L-Box H2/H1	$\geq$ 0.8
8.	Fill Box	$\geq$ 90%

416.4 MEASUREMENT AND PAYMENT

416.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters of concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes and conduits, etc., in case where their cross-sectional areas exceed 500 square centimeters.

The measurement shall not include any concrete used in the construction of cofferdams or false work.

The volume involved in fillets, scorings, or chamfers ten square centimeters in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for.

416.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below as shown in the Bill of Quantities, which prices and payment shall be full compensation for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

Pay Item No.	Description.	Unit of Measurement
416a	Self Compacting Concrete, Grade ____ Below Ground	CM
416b	Self Compacting Concrete, Grade ____ On Ground	CM
416c	Self Compacting Concrete, Grade ____ Elevated	CM

SECTION 417 FIBER REINFORCED CONCRETE (FRC)

417.1 DESCRIPTION

This work shall consist of furnishing, and placing of Fiber Reinforced Concrete (FRC) of grade of concrete and type of fibers required in accordance with these specifications, and in conformity with the requirements shown on the Drawings and Special Provisions or as directed by the Engineer. FRC consists of the use of short discrete randomly distributed fibers within the concrete matrix to increase tensile strength, toughness of concrete, abrasion and impact resistance, and reduction of shrinkage and temperature cracks.

In addition to these specifications, FRC shall conform to ASTM C1116/C1116M.

Broad areas of application of FRC are shotcrete, structural elements particularly slabs, precast concrete products, concrete repair work, Rigid Pavements, Canal Concrete lining etc.

417.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements hereinafter given. Test reports from approved sources shall be submitted to the Engineer for all materials used. These reports shall show the results of chemical and physical tests made.

417.2.1 Fiber Reinforcement

Fiber Reinforcement shall consist of any of the following four types of fibers:

Type-1: Steel Fibers consisting of stainless steel, alloy steel, or carbon steel fibers conforming to ASTM A820/A820M.
Type-2: Glass Fibers consisting of alkali-resistant (AR) glass fibers conforming to ASTM C1666/C1666M.
Type-3: Synthetic Fibers consisting of polyethylene, polypropylene / fibrillated polypropylene (conforming to ASTM D7508/D7508M), nylon or carbon fibers.
Type-4: Natural Fibers consisting of cellulose fiber conforming to ASTM D 7357.

For Type-3 & 4 Fibers, documentary evidence shall be produced confirming their resistance to deterioration when in contact with the moisture and alkalis present in cement paste and the substances present in admixtures throughout the anticipated useful life of the structure.

Minimum fibers length used for durability purposes shall be 1.5 times max. size of coarse aggregate, but need not be more than 30 cm, for all types of fibers used for durability.

For Structural purposes, only steel fibers shall be used. Other types of fibers shall only be used to increase durability and toughness of concrete.

Steel fibers up to 60 cm length shall be used for structural purposes as reinforcement in slabs. Steel fibers shall be cut fibers, sheared fibers or
machined fibers, with indentations to provided good bonding properties with concrete.

Diameter of Steel fibers shall be within the range of 0.3mm to 0.9mm.

Aspect Ratio of Steel fibers (length/diameter) shall range from 20 to 100.

Polypropylene fibers up to 63mm length shall be used for improvement of durability. The fiber shall have fibrillation to improve concrete bonding.

Diameter of Polypropylene fibers shall be within the range of 19 to 50 micron.

Proportions of Type-1 Fibers:
Fiber content in fresh concrete shall range between i.e. 40 to 160 Kg/m^3 by weight.

Proportions of Type-2 Fibers:
Fiber content in fresh concrete shall range between 48 to 84 Kg/$m^3$for premix concrete and up to 132 kg/m^3 for sprayed concrete.

Proportions of Type-3 & 4 Fibers:
Fiber content in fresh concrete shall range between 1.8 to 8.9 Kg/m^3 for Type-3 & Type-4 fibers except for carbon fibers. Carbon fiber content in fresh concrete shall range between 32 to 65 Kg/m^3.

The specified range of proportions of various fibers stated here above can be adjusted as per requirements of the project after getting necessary approvals from the Engineer.

The actual proportions of fibers in concrete shall be according to the mix design.

417.2.2 Concrete

All constituent materials of concrete shall conform to items 401 or 414 of this specification as per type of concrete.

417.3 CONSTRUCTION REQUIREMENTS

Construction requirements for FRC i.e. mix design, batching, mixing, transportation, placing, compaction, curing and testing etc., shall be the same as that for concrete of same grade as per items 401 or 414 of this specification as per type of concrete. In addition following requirements shall be met for FRC.

Fiber shall be mixed with the fresh concrete in the mixer/batching plant or in the agitator truck. During mixing of fibers it shall be ensured that fibers are uniformly mixed with fresh concrete and do not lump together. Fibers shall be dispensed in the concrete through dispensers or bundled with water soluble adhesive and mixed in concrete. When fibers are mixed in agitator truck, concrete shall be mixed at high speed.

Mixing of FRC requires 2 to 4 times more energy than normal concrete. Hence, for mixing of FRC forced-action batch mixer shall be used instead of
gravity mixers, and mixing time shall be established by trial runs prior to start of construction activity.

Special care needs to be taken to ensure that fibers are not massed together in a ball during mixing, transportation and placing.

FRC may exhibit reduced consistency due to presence of fibers. To compensate for this and achieve desired consistency, necessary admixtures such HRWR may have to be incorporated in the mix design.

Pumping loads are greater for FRC as compared to normal concrete hence pumping system shall be appropriate for the required job. Flexible piping liable to abrasion from fibers shall not be used for pumping FRC. Size of pipe shall be adequate to ensure free flow of concrete and fibers so that fibers do not lump together in the pipe.

417.4 MEASUREMENT AND PAYMENT

417.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters of FRC of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of FRC shall be made for the volumes of draining holes, weep holes, pipes and conduits, etc., in case where their cross-sectional areas exceed 500 square centimeters.

The volume involved in fillets, scorings, or chamfers ten square centimeters in cross-sectional area or less shall be disregarded when measuring the quantity of FRC to be paid for.

417.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below that as per shown in the Bill of Quantities which prices and payment shall be full compensation also for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

For all FRC structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the FRC structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

Pay Item No.		Description.	Unit of Measurement
417a		FRC Class A.....	
	(i)	Under Ground	CM
	(ii)	On Ground	CM
	(iii)	Elevated	CM
417b		FRC Class C	
	(i)	Underground	CM
	(ii)	On Ground	CM
	(iii)	Elevated	CM
417c	(i)	FRC Class D_1	CM
	(ii)	FRC Class D_2	CM
	(iii)	FRC Class D_3	CM
417d		FRC Class Y	CM
417e		Precast FRC, Class.....	CM

SECTION418 HIGH-PERFORMANCE CONCRETE (HPC)

418.1 DESCRIPTION

High Performance Concrete shall be highly durable concrete with 28 days compressive cylinder strength of 48 MPa (7,000 psi) or more. The item consists of requirement of materials to produce high-performance concretes, construction requirements for mixing, placing, consolidation and curing, mix design and quality control/assurance during the construction phase.

In addition to the high strength requirement, high performance concrete may be required to meet anyone or more of the following properties as per requirements of the project and as specified in the Contract Documents.

TABLE 418-1: SELECTED PROPERTIES OF HIGH-PERFORMANCE CONCRETE

Property	Test Method	Criteria that may be specified
High-early compressive strength	ASTM C 39	20 to 28 MPa (3000 to 4000 psi) at 3 hours to 3 days
High-early flexural strength	ASTM C 78	2 to 4 MPa (300 to 600 psi) at 3 hours to 3 days
Abrasion resistance	ASTM C 944	0 to 1 mm depth of wear
Low permeability	ASTM C 1202	500 to 2000 coulombs
Chloride penetration	AASHTO T 259 & T 260	Less than 0.07% Cl at 6 months
High resistivity	ASTM G 59	
Low absorption	ASTM C 642	2% to 5%
Low chlorine diffusion coefficient	ASTM C 1556	Less than 1000 x 10^{-13} m/s
Resistance to chemical attack	Expose concrete to saturated solution in wet/dry environment	No deterioration after 1 year
Sulfate attack	ASTM C 1012	0.10% max. expansion at 6 months for moderate sulfate exposures or 0.50% max. expansion at 6 months for severe sulfate exposure
High modulus of elasticity	ASTM C 469	More than 40 GPa (5.8 million psi)
High resistance to freezing and thawing damage	ASTM C 666, Procedure A	Durability factor of 95 to 100 at 300 to 1000 cycles (max. mass loss or expansion can also be specified).
High resistance to deicer scaling	ASTM C 672	Scale rating of 0 to 1 or mass loss of 0 to 0.5 kg/m^3 after 50 to 300 cycles.
Low shrinkage	ASTM C 157	Less than 400 millionths
Low creep	ASTM C 512	Less than normal concrete

418.2 MATERIAL REQUIREMENTS

All materials for High Performance Concrete shall generally conform to the requirements of Item 401 “Concrete” of this specification, in addition to the following mandatory requirements.

TABLE 418-2: MATERIALS SPECIFICATIONS

Material	Classification	Specification
Portland cement	Type I, II, III, or V	ASTM C 150
Blended hydraulic cement	Type IS, IP, I (SM), or I (PM)	ASTM C 595
Hydraulic cement	Type GU, HE, HS, MS, or MH	ASTM C 1157
Fly ash	Class C or F	ASTM C 618
Ground-granulated blast-furnace slag	Grade 100 or 120	ASTM C 989
Natural pozzolans	Class N	ASTM C 618
Silica fume (slurry or densified)		ASTM C 1240
Coarse aggregate	No. 67, 7, 8, or 89	ASTM C 33
Fine aggregate		ASTM C 33
Chemical admixtures	Types A to G	ASTM C 494
Super-plasticizers	Type I & II	ASTM C 1017
Air-entraining admixtures		ASTM C 260
Water		ASTM C 1602

418.2.1 Cement

Selection of cement for high-strength concrete shall not be based only on mortar-cube tests but shall also include tests of comparative strengths of concrete at 28, 56, and 90 days. Cement that yields the highest concrete compressive strength at designated testing age shall be preferable. For high-strength concrete, cement shall produce minimum 7-days mortar-cube strength of 30MPa (4,350 psi) or more when tested in accordance with ASTM C-109.

Trial mixtures with cement contents between 400 and 600 kg/cu. m shall be made for each type of cement being considered for the project. Amounts may vary depending on target strengths. Other than decreases in sand content as cement content increases, the trial mixtures shall be as nearly identical as possible.

418.2.2 Coarse Aggregates

In high-strength concrete, careful attention shall be given to aggregate size, shape, surface texture, mineralogy, and cleanness. To find the optimum size of aggregate which will give maximum concrete strength, trial batches shall be made with 19 mm (3/4 inch) and smaller coarse aggregates gradations and varying cement contents. The gradations for various sizes of aggregate shall be as follows:

TABLE 418-3: GRADING REQUIREMENTS FOR COARSE AGGREGATES

ASTM Size Number	Nominal Size	Amount Finer than Each Sieve (Square Opening), Mass Percent							
		25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 µm
67	19.0 to 4.75 mm	100	90 to 100	…	20 to 55	0 to 10	0 to 5	…	…
7	12.5 to 4.75 mm	...	100	90 to 100	40 to 70	0 to 15	0 to 5	…	…
8	9.5 to 2.36 mm	...	…	100	85 to 100	10 to 30	0 to 10	0 to 5	…
89	9.5 to 1.18 mm	...	…	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5

Coarse aggregates used in high-strength concrete shall be clean, that is, free from detrimental coatings of dust and clay. For this purpose aggregates shall be washed at production quarry before delivery to the batching plant. Combining single sizes of aggregates to produce the required grading shall be adopted for close control and reduced variability in the concrete.

418.2.3 Fine Aggregates

Sand with a fineness modulus (FM) between 2.8 and 3.2 shall be used in preparation of High Performance Concrete. FM shall not vary by more than 0.10 from the Mix Design FM selected, for the duration of the project. Sand Equivalent value of aggregates shall not be less than 85. Gradation of Fine aggregate shall be as follows:

TABLE 418-4: GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight.
3/8 inch (9.5mm)	100
No. 4 (4.75mm)	95-100
No. 8 (2.36mm)	80-100
No. 16 (1.18mm)	50-85
No. 30 (600□m)	25-60
No. 50 (300□m)	5-30
No. 100 (150□m)	0-10
No. 200 (75□m)	0

Fine and coarse aggregates shall be free from any coatings that could impair paste aggregate bonding. Necessary precautions shall be taken by the contractor at the concrete production facility to keep the aggregates clean and prevent contamination.

418.2.4 Chemical Admixtures

The use of chemical admixtures such as water reducers, retarders, high-range water reducers (HRWR) or superplasticizers shall be as per mix design. The chemical admixtures shall be compatible with cement and supplementary cementing materials.

Air entraining admixtures shall only be used in High Strength Concrete when specified in the contract documents and approved by the Engineer in writing.

418.2.5 Supplementary Cementing Material

Fly Ash, Silica Fume, Ground-granulated blast furnace slag (GGBFS) or High-reactivity metakaolin (HRM) shall be used in the production of high-strength concrete as per approved mix design. These supplementary cementing materials shall be added at following dosage ranges in preparation of Mix design:

Fly Ash	15 – 40% by mass of cementitious material
GGBFS	30 – 50% by mass of cementitious material
Silica Fume	5 – 10% by mass of cementitious material
HRM	5 – 15% by mass of cementitious material

Silica Fume and HRM shall be used to reduce permeability of concrete in addition to increasing its strength.

The water-to-cementing materials ratio shall be adjusted so that equal workability becomes the basis of comparison between trial mixtures. For each set of materials, there will be optimum cement-plus-supplementary cementing materials content at which strength does not continue to increase with greater amounts and the mixture becomes too sticky to handle properly. Blended cements containing fly ash, silica fume, slag, or calcined clay can be used to make high-strength concrete with or without the addition of supplementary cementing materials.

418.2.6 Mix Design

The trial mixture approach shall be used for selecting proportions for high-strength concrete. To obtain high strength, it is necessary to use a low water to cementing materials ratio and a high Portland cement content. The unit strength obtained for each unit of cement used in a cubic meter of concrete shall be plotted as strength efficiency to assist with mix designs.

High performance concretes shall be specifically prepared for each type of application. After addition of HRWR, the concrete shall have a slump of around 200 mm (8 in.) when measured as per ASTM C-143 for most applications, unless otherwise specified.

418.2.6.1 Mix Design Procedure

Mix Design shall be carried out as per ACI-211.4R-08 (or later). Mix designs of high performance concrete using Fly Ash, Silica Fume or GGBFS shall be prepared in an approved laboratory complying with ASTM C-1077.

Mix Design Submittal Requirements.

Unless otherwise specified, concrete mixture proportions shall be submitted for approval at least 60 days before production.

Each concrete mixture proportion submittal shall include, as a minimum, the following information:

- Project identification;
- Name and address of concrete supplier and concrete production facility;
- Date mixture prepared;
- Date of report;
- Mixture design designation;
- Specified compressive strength of concrete and other specified properties at the required age;
- Concrete mixture proportions, based on the saturated surface-dry weights of the coarse and fine aggregates;

- Test results showing material properties of fine and coarse aggregates, including gradations, relative density (specific gravity), absorption, acceptance criteria, and compliance;
- Names and locations of all material sources;
- Certificates of compliance for cement, supplementary cementitious materials, aggregates and admixtures, accompanied by test reports showing test results, acceptance criteria, and compliance;
- Statement of methods for site adjustments using admixtures, if proposed;
- Documentation demonstrating that the proposed mixture proportions produce concrete meeting the specified properties.

418.2.6.2 Mixture Proportions, Trial and Field Batches

The proportioning of mixtures and requirements for trial batches of concrete shall be carried out to fulfill following requirements.

Trial batch tests: Contractor shall submit trial batch test results including test dates for each mixture proposed for use on the project.

Field verification tests: Contractor shall submit field verification test results including test dates for each mixture proposed for use on the project.

Mixture proportions: Concrete mixtures shall be proportioned to attain the properties at the acceptance ages specified in the contract documents. The contractor shall submit the trial batch test results including test dates to the Engineer for review and acceptance.

Field verification tests: Field verification of the compressive strength and other properties specified in the contract documents shall be performed before the start of construction.

Laboratory trial mixtures: All trial mixtures shall be prepared and tested by an approved laboratory.

Field verification: Field verification tests shall simulate the same mixing, transportation, and placing procedures proposed for use on the project. Field verification tests shall be performed in accordance with applicable ASTM standards. The batch sizes for field verification tests shall be representative of the batch sizes proposed for use on the project. For each field verification batch to be evaluated, and for each test age, a minimum of three specimens for each specified property shall be tested, unless a greater number of specimens is required for a specific test. Testing of fewer than three specimens for each specified property shall require prior approval by the Engineer.

418.3 CONSTRUCTION REQUIREMENTS

All requirements of Item 401 shall be followed in addition to the following specific requirements for HPC.

418.3.1 Mixing

Batching and mixing sequences shall be optimized during the trial mix phase so that concrete does not become sticky or “balling” of mix does not occur during transport. Where transit truck mixing is unavoidable, the concrete load shall be reduced to 90% of the rated capacity of the trucks.

Unless otherwise specified, the minimum batch size shall be three (3) cubic meters, unless prior approval for a smaller batch size is obtained from the Engineer.

If HPC is to be procured from premix concrete producers, prequalification of concrete suppliers shall be carried out. Ready-mix concrete shall comply with requirements of ASTM C-94. In a prequalification procedure, one or more loads of the proposed mixture shall be cast into a trial mock-up. The fresh concrete shall be tested for slump, air content, temperature, and density. Cores shall be taken from the hardened concrete to carry out further tests e.g. compressive strength, modulus of elasticity etc. as per design requirements.

Following requirements shall be adhered to in preparation of High Performance Concretes.

Mixing: All batches shall be mixed a minimum of 100 revolutions, or for a period sufficient to comply with the concrete uniformity requirements of ASTM C 94, whichever is greater.

Washing trucks: Trucks shall be completely washed out and emptied of all wash water before receiving a batch of high-strength concrete.

Automatic measurement of moisture content: The concrete production facility shall be equipped with a calibrated automated device to measure the moisture content of the fine aggregates and automatically adjust the amount of batch water required. The moisture measurement device shall be calibrated at least every 28 days during the production of high-strength concrete.

Measuring moisture content during production: Before the start of the production each day, the moisture content of the coarse aggregates shall be determined in accordance with ASTM C 566. Moisture content measurements shall also be made at any other time during production when it is believed the moisture content of the coarse aggregates has changed by more than 1%.

Moisture content records: A record of aggregate moisture content testing shall be available for inspection at the concrete production facility at all times during batching.

Rinsing trucks: Rinsing of the delivery truck collection hoppers and internal drum components after batching shall not be permitted, except under the direct onsite supervision of trained quality control or plant supervisory personnel. The amount of water used for rinsing the truck collection hoppers and internal drum components, after batching and before the truck leaves the plant, shall be kept to a minimum, and shall not exceed eleven (11) liters of water per batch, and shall be considered as part of total water in the load.

Batch tickets: Unless otherwise specified, each batch ticket shall include, as a minimum, the following information:

- Name of ready-mix company and batch plant, or batch plant number;
- Serial number of ticket;
- Date;
- Truck number;
- Name of purchaser;
- Specific designation of job (name and location);
- Specific class or designation of the concrete using the same nomenclature as employed in project specifications;
- Amount of concrete in cubic yards (cubic meters);
- Time loaded or time of first mixing of cement and aggregates;
- Amount of water added by receiver of concrete and their initials;
- Total amount of water in the load as batched.

Additional information for certification purposes as designated by the Engineer and required by the job specifications shall be furnished. This information may include:

- Reading of revolution counter at the first addition of water;
- Type, brand, and amount of cement;

- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans;
- Grade, brand, and amount of ground-granulated blast furnace slag;
- Type, brand, and amount of silica fume;
- Type, brand, and amount of admixtures;
- Type, brand, and amount of fiber reinforcement;
- Source and amount of each metered or weighed water;
- Information necessary to calculate the total mixing water. Total mixing water includes free water on aggregates, batch water (metered or weighed) including ice batched at the plant, and water added by the truck operator from the mixer tank;
- Maximum size of aggregates;
- Mass (amount) of fine and coarse aggregates;
- Ingredients certified as being previously approved; and
- Signature or initials of producer's representative.

Delivery tickets: Delivery tickets shall be filled out completely and shall not be surrendered by drivers until completion of discharge of concrete except for review by the inspector.

Addition of water: The addition of water to high strength concrete after the concrete has been batched shall not be permitted, unless the addition of water is carried out in strict accordance with procedures preapproved by the licensed design professional.

Mixing time: Unless otherwise specified, discharge of the concrete shall be completed within 1-1/2 hours, or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. These limitations are permitted to be waived by the Engineer if the concrete is of such slump that after the 1-1/2 hour time or 300-revolution limit has been reached it can be placed and consolidated, without the addition of water to the batch. In hot weather or under conditions contributing to quick stiffening, the time of 1-1/2 hours may be reduced by the Engineer.

418.3.2 Placing, Consolidation and Curing

Close liaison between the contractor and the concrete producer shall be ensured to allow concrete to be discharged rapidly after arrival at the jobsite. Final adjustment of the concrete shall be supervised by the concrete producer's technicians at the site, by a concrete laboratory, or by a consultant familiar with the performance and use of high performance concrete.

Delays in delivery and placing must be eliminated; sometimes it may be necessary to reduce batch sizes if placing procedures are slower than anticipated. Rigid surveillance must be exercised at the jobsite to prevent any addition of re-tempering water. Increases in workability should only be achieved by the addition of a super-plasticizer (HRWR). This should be done by a qualified technician. On-site addition of a high-range water-reducing admixture of the same brand and type used at the concrete production facility shall be permitted at the discretion of the Engineer. A procedure shall be submitted by the contractor for on-site addition of HRWR admixture and approved by the Engineer before the start of construction. A record of job-site-added HRWR admixture shall be maintained and shall be available at the project site at all times. A site-added HRWR admixture shall be introduced to the batch by means of a pipe or wand capable of placing the product near the center of the mixing drum, and using an automated admixture metering device. The batch shall then be remixed until uniform. An admixture shall be introduced at the site only in accordance with the recommendations of the admixture manufacturer. If a batch of concrete becomes segregated in the opinion of the Engineer or his representative at site, as a result of on-site addition of excessive high-range water-reducing admixture, that batch shall be rejected.

Concrete shall be vibrated as quickly as possible after placement in the forms. Consolidation of HPC shall be carried out in accordance with ACI-309R. High-frequency vibrators should be small enough to allow sufficient clearance between the vibrating head and reinforcing steel. The amount of vibration required to achieve full compaction shall be determined by onsite trials. Consistency of HPC shall be kept such that minimum vibration is needed to achieve full consolidation.

High-strength concrete is often difficult to finish because of its sticky nature. High cementitious materials contents, large dosages of admixtures, low water contents, and air entrainment all contribute to the difficulty of finishing these concretes. Because the concrete sticks to the trowels and other finishing equipment, finishing activities should be minimized. The finishing sequence shall be modified from that used for normal concrete.

Appropriate curing methods as per ACI-308 for various structural elements shall be selected in advance to ensure proper curing of HPC.

Immediate application of curing compound on placed HPC shall not be allowed although evaporation retardants may be applied immediately after finishing. Wet curing shall be carried out for HPC for the first 7 days followed by application of two coats of curing compound. Adequate moisture and favorable temperature conditions shall be maintained for a prolonged period, particularly when 56 or 90-days concrete strength are specified. Wet curing shall be continuous and no part of concrete shall be allowed to be left for even a short time dry during wet curing period.

Following additional curing considerations shall be adopted for HPC. Where very low water-cement ratios are used in flatwork (slabs and overlays), and particularly where silica fume is used in the mixture “fog curing” or evaporation retarders shall be applied to the concrete immediately after the surface has been struck off.

Water curing of vertical members is usually impractical, and other curing methods shall be employed, such as leaving the forms in place for 2 to 3 days.

Hot weather concrete placement temperature:
Unless otherwise specified, HPC delivery temperature shall not exceed 77°F (25°C) and placement temperature shall not exceed 95°F (35°C). Higher placement temperatures shall be permitted only if it can be demonstrated that placing the concrete at higher temperatures will not be detrimental to any specified concrete property. The in-place concrete temperature at any time after placement is completed shall not exceed 158°F (70°C).

Cold weather concreting:
Unless otherwise specified, when high-strength concrete is placed in cold weather as defined in Item 401, concrete temperature limits shall be in accordance with Table 418-5. Unless otherwise specified, the maximum rate of concrete temperature decrease under cold weather conditions shall be in accordance with Table 418-5.

TABLE 418-5: COLD WEATHER CONCRETING:
LIMITS ON CONCRETE TEMPERATURES AND RATE OF TEMPERATURE DECREASE

		Minimum Section Dimension			
		<12 in.	12 to 36 in.	>36 to 72 in	>72 in.
Minimum concrete temperature as mixed, for indicated air temperature	Air temperature above (-1) ℃	16 ℃	13 ℃	10 ℃	7 ℃
	Air temperature (-18) ℃ to (-1) ℃	18 ℃	16 ℃	13 ℃	10 ℃
	Air temperature below (-18) ℃	21 ℃	18 ℃	16 ℃	13 ℃
Minimum concrete temperature as placed and maintained		13 ℃	10 ℃	7 ℃	4 ℃
Maximum concrete temperature as placed		24 ℃	21 ℃	18 ℃	16 ℃
Maximum allowable temperature drop in concrete in first 24 hours after removal of formwork, insulation, or both		28 ℃	22 ℃	17 ℃	11 ℃

In mass concrete, the difference between the warmest and the coolest portion of the member shall not exceed 35 ℉ (20 ℃), unless it can be demonstrated through substantiated thermal modeling that a higher temperature differential is not detrimental to the structure.

Following additional placing requirements shall be met by the contractor at the job site:

Placing equipment: Equipment for placing the concrete shall have adequate capacity to perform its intended function. Stand-by equipment shall be available in the event of an equipment breakdown.

Depositing concrete: Concrete shall be deposited at or as close as possible to its final position in the structure. Buggies, chutes, buckets, hoppers, or other means shall be permitted to move the concrete as required.

Concrete of different strengths: In applications where concrete with two different strengths are being placed against one another, the higher-strength concrete shall be placed before the lower-strength concrete, without formation of a cold joint.

418.3.3 QUALITY CONTROL

Contractor shall maintain independent Quality Assurance (QA) and Quality Control (QC) teams for HPC project who shall monitor all aspects of concrete production, mixing, placing and curing etc. The on-site material testing laboratory shall comply with ASTM C-1077

Tests on concrete shall be made in strict accordance with standard procedures, additionally following requirements shall also be complied with, especially where specified strengths are 70 MPa (10,000 psi) or higher. Cardboard cylinder molds, which can cause lower strength test results, shall be replaced with reusable steel or plastic molds. Capping of cylinders shall be done with great care using high strength capping compounds. Lapping (grinding) the cylinder ends may be done as an alternative to capping. For high performance concrete, end grinding to a flatness tolerance of 0.04 mm shall be achieved.

Testing machines shall be of approved make and shall be certified to test high strength concretes.

418.3.3.1 Concrete Plant

Concrete Batching Plants used to produce high-strength concrete shall be inspected regularly and certified to comply with the Check List requirements of the NRMCA-USA "Certification of Ready Mixed Concrete Production Facilities". QA/QC of concrete plant shall be carried out continuously until consistently acceptable batching is achieved. Thereafter, spot checking the plant shall be done unless the complexities of the project demand full-time monitoring. Full-time inspection shall be carried out at the batching plant for concretes with design strengths greater than 70Mpa (10,000 psi).

QA/QC shall be carried out to ensure that the facilities, moisture meters, scales, and mixers (central or truck, or both) meet the project specification requirements and that materials and procedures are as established in the planning stages. QA/QC shall also be carried out regarding batching high-strength concrete, such as using proper sequencing of ingredients, especially when pozzolans or ground slag are used. Scales, flow meters, and dispensers shall be checked monthly for accuracy, and shall be calibrated every six months. Moisture meters shall be checked daily. These checks and calibrations shall be documented. Plants that produce high-strength concrete shall have printed records for all materials batched.

The QC or QA inspector shall be present at the batching console during batching and shall verify that the accepted types and amounts of materials are batched. Site tolerances and batch weights shall fall within the allowable tolerances as shown in Table 418-6.

TABLE 418-6: SITE TOLERANCES

Sr. No.	Description	Tolerance
1 a.	Specified slump < 50 mm	±15 mm
b.	Specified slump 50 to 100 mm	±25 mm
c.	Specified slump > 100 mm	±40 mm
2.	Air Entrainment	±1.5 %
3 a.	Cement	±1.0 %
b.	Cement + Supplementary Cementitious Material	±1.0 %
4 a.	Individual size aggregate weight	±2.0 %
b.	Cumulative aggregate weight	±1.0 %
5.	Chemical Admixtures	±3.0 %
6 a.	Compressive strength test (average of three cylinders)	≥ specified fc'
b.	Compressive strength test (any individual test from 6a)	≥ (fc'-500) psi

When not witnessing the entire batching operation, QA/QC personnel shall perform or witness the following tests at least once daily (or once per eight-hour shift):

- Moisture content of fine and coarse aggregates in accordance with ASTM C 566.
- Aggregate gradations (fine and coarse) in accordance with ASTM C 136.
- Material finer than the 75-µm (No. 200) sieve in accordance with ASTM C 117.

Moisture content tests shall be repeated after rain and the other tests shall be repeated after deliveries of new batches of materials.

Substitutions of chemical admixtures shall not be allowed without the prior approval of the Engineer. Reference samples of cementitious materials shall be taken at least once per day or per shipment for tests later on to investigate low strengths or other deficiencies.

Sources of additional mixture water such as “wash water” or any “left-over” concrete remaining in the truck drum prior to batching shall be identified. These shall be emptied from the truck prior to batching.

418.3.3.2 Delivery

Truck mixers used to transport high-strength concrete shall be inspected regularly and certified to comply with the Check List requirements of the NRMCA-USA “Certification of Ready Mixed Concrete Production Facilities”. Truck mixers shall be equipped with a drum revolution counter, and their fins shall comply with NRMCA criteria.

The concrete truck driver shall provide a delivery ticket that contains the complete information specified in item 418.3.1. Every ticket shall be reviewed by the inspector prior to discharge of concrete.

If the batch is redosed at site, the amount of admixture added to the truck with a calibrated delivery system shall be recorded and the truck drum shall be turned at least an additional 30 revolutions at mixing speed. Therefore, the delivery ticket shall also provide a space for recording the following information:

- Water or admixtures added by authorized personnel at the job site.
- Approximate quantity of concrete in truck when additional water or admixture is added.
- Number of drum revolutions at mixing speed after the addition of water or admixture.

Addition of water at the job site shall be permitted only after prior written permission of the Engineer and provided that the maximum specified water-cementitious materials ratio is not exceeded.

418.3.3.3 Placing

Preparations at the project site shall be completed prior to delivery of the first truck load of concrete. QA/QC personnel shall verify that forms, reinforcing steel, and embedded items are ready and that the placing equipment and vibration equipment (including standby equipment) are in working order prior to the contractor placing concrete.

Forming of cold joints between successive loads or between different types of concretes shall not be allowed.

418.3.3.4 Curing

QA/QC personnel shall verify that the accepted methods of curing are properly employed in the work.

The QA/QC inspector shall monitor and record ambient temperatures and temperatures at the surface and center of large concrete components so that the design/construction team can effectively make any adjustments, such as changes in mixture proportions or the use of insulating forms, during the course of the project. Concrete delivered at temperatures exceeding specification limits shall be rejected, unless alternative procedures have been approved by the Engineer. The inspector shall monitor that curing procedures are according to project specifications, particularly those at early ages to control the formation of plastic shrinkage cracks.

418.4 MEASUREMENT AND PAYMENT

418.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters of concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes and conduits, etc., in case where their cross-sectional areas exceed 500 square centimeters.

The measurement shall not include any concrete used in the construction of cofferdams or false work.

The volume involved in fillets, scorings, or chamfers ten square centimeters in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for.

418.4.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below as shown in the Bill of Quantities, which prices and payment shall be full compensation for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

Pay Item No.	Description.	Unit of Measurement
418a	High Performance Concrete, Grade ____ Below Ground	CM
418b	High Performance Concrete, Grade ____ On Ground	CM
418c	High Performance Concrete, Grade ____ Elevated	CM

DRAINAGE
AND
EROSION WORKS

DRAINAGE AND EROSION WORKS

SECTION 500 GENERAL

The Contractor shall so schedule the construction of drainage works that the discharge of runoff from rain or other sources, both during and after construction, is properly provided for.

To avoid damage to works in course of construction, the Contractor shall provide adequate means of protection, including all necessary temporary outlet ditches, dams or diversion channels, culverts, ditches or other drainage works for the discharge of runoff water during construction and which shall be kept clear of all obstructions that might impede the flow of water.

These requirements shall be met without additional payment and all costs thereof shall be included in the bid prices for any items under the contract.

Drainage structures shown on the Drawings and their estimated total quantities are not to be taken as final. The Engineer, who will inform the Contractor of them in writing, will decide the final quantities.

SECTION 501 REINFORCED CONCRETE PIPE CULVERTS

501.1 DESCRIPTION

This work shall consist of the construction, reconstruction or repair of culverts and water drainage structures in accordance with these specifications, and in conformity with the lines, grades and dimensions shown on the Drawings or ordered by the Engineer.

The work shall include the furnishing and laying of the pipe, and the construction of such joints and connection to other pipes, catch basins, or other structures as may be required to complete the work as shown on the Drawings or as required by the Engineer.

The work shall also include the removal and disposal of existing culverts and structures except such portions as may be required or permitted by the Engineer to be left in place.

The Engineer reserves the right to inspect and test the pipe after its delivery to the work. Injurious defects revealed subsequent to acceptance of pipe and prior to its installation in the work shall be cause for rejection.

The Contractor shall not order and deliver the pipes for any work until the Engineer has approved a list of sizes and lengths.

501.2 MATERIAL REQUIREMENTS

The pipes shall meet the requirements of the AASHTO M-170, class II and IV as called for in the Bill of Quantities.

Cement, sand and water shall conform to the requirements specified in item 401-Concrete, except that the grading of sand shall meet the requirements of AASHTO M-45.

Steel reinforcement shall conform to the requirements specified in Item 404 of these specifications.

Rubber ring gaskets for rigid pipe, if required, shall conform to the requirements of AASHTO M-198.

501.3 MANUFACTURING REQUIREMENTS

Reinforced concrete pipe culverts shall conform to the requirements of AASHTO M-170.

501.3.1 Dimensions and Strength Test Requirements

Shell thickness, the quantity of circular reinforcement and the strength per linear meter for the various sizes of pipe shall conform to the minimum requirements listed in related Table as per AASHTO M-170 latest addition.

501.3.2 Reinforcement

Each line of reinforcement shall be assembled into a cage, which shall contain sufficient longitudinal bars or members extending through the barrel of the pipe to maintain the reinforcement rigidly in exact shape and correct position within the form. If the splices are not welded, the reinforcement shall be lapped not less than 30 times diameter for bars and 40 times diameter for cold-drawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength of not less than three thousand seven hundred (3,700) Kgf / Sq. cm. The spacing centres of adjacent rings of the circumferential reinforcement (pitch) shall not exceed 10 cm. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of ± six (6) mm.

501.3.3 Joints

The ends of reinforced concrete culvert pipes shall be the ogee or spigot and socket types and of such design that when laid the joints shall form a continuous conduit with a smooth and uniform interior surface.

501.3.4 Tolerances

Variations in internal diameter and wall thickness shall not exceed the limit specified in relevant “Table for Allowable Tolerances” for reinforced concrete pipes in these Specifications.

501.3.5 Absorption

The water absorption of the concrete pipe shall not exceed eight (8) per cent of the dry weight as determined in AASHTO designation T-33.

501.3.6 Curing

Pipes shall be subjected to any one of the methods of curing described in the following paragraphs or to any other method or combination of methods, approved by the Engineer's Representative, that will give satisfactory results, provided that no pipe shall be used within a period of fourteen (14) days after curing. All pipes shall be marked with the date of casting.

i) Steam Curing

Pipes shall be placed in a curing chamber, free from outside draughts, and cured in a moist atmosphere, maintained at a temperature between thirty eight (38) and fifty four (54) degree C by the injection of steam for a period of not less than twenty four (24) hours or, when necessary, for such additional time as may be needed to enable the pipe to meet the strength requirements. When a curing chamber is not available, pipes may be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature and for the time specified above. The enclosure shall be so erected as to allow full circulation of steam around the entire pipe. The interior surfaces of the curing room or canvas jackets and the surfaces of the pipes shall be entirely moist at all times.

ii) Water Spray Curing

Under the conditions of enclosure prescribed in (i) above, pipes may be cured by subjecting them to a continuous or frequently applied fine spray of water in an enclosure maintained at a temperature of not less that twenty one (21) degree C for a period of not less than seventy two (72) hours, or such additional time as may be necessary to meet the strength requirements.

iii) Saturated Cover Curing

The sides and top of each pipe may be covered with heavy Hessian or other suitable material, saturated with water before applying and kept saturated with water at a temperature of not less than twenty one (21) degree C for seventy two (72) hours, or such additional time as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe. If the temperature of the water is less than twenty one (21) degree C, the curing period shall be increased as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe.

501.3.7 Workmanship and Finish

All pipes shall be substantially free from fractures, large or deep cracks, honeycombing, open texture, spells and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis.

501.3.8 Inspection

The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, test and approval at the place of manufacture. The Contractor shall make the necessary arrangements with the manufacturer to set aside in a separate area all pipes for which he desires approval.

i) Test Specimens

Pipes for the purpose of tests shall be furnished free of cost by the Contractor and will be selected at random by the Engineer. The number of sections required for test will not be more than two (2) percent except that at least one of every size will be selected. Pipes for tests shall conform to these specifications.

ii) Test Equipment

If the manufacturer has equipment for conducting the crushing strength test, the Contractor shall make the necessary arrangements to have the required tests conducted in the presence of the Inspector designated by the Engineer. If the testing facilities are not available at the point of manufacture, the Contractor shall make the necessary arrangements for furnishing & testing, at no cost to the Employer, the pipe sections selected by the Inspector to a laboratory approved by the Engineer.

iii) Re-test

Should any of the test specimens provided in accordance with the requirements listed in paragraph (1) above fail to meet the test requirements, the Contractor will be allowed a re-test on two additional specimens for each specimen that failed, and the pipe will be acceptable only when all the these retested specimens meet the strength requirements.

501.3.9 Rejection

Pipes shall be subject to rejection on account of failure to conform to any of the above specification requirements or on account of any of the following:-

i) Fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joints exist in more than ten (10) per cent of the pipes inspected, however, the defective pipes shall be rejected.

ii) Defects that indicate imperfect mixing and moulding.

iii) Surface defects indicating honeycombing or open texture and exposure of reinforcement including rust marks caused by inadequate concrete cover.

iv) Spalls deeper than one half the depth of the joint or extending more than ten (10) cm around the circumference. If spalls not deeper than one half of the joint or extending not more than ten (10) cm around the circumference exist in more than ten (10) per cent of the pipes, however, the defective pipes shall be rejected.

v) Misplaced reinforcement already exposed or verified by checking with an approved concrete reinforcement cover meter.

501.4 CONSTRUCTION REQUIREMENTS

501.4.1 Excavation

A trench shall be excavated to the depth and grade established by the Drawings. The bottom of the trench shall be shaped to conform to the shape of the pipe for at least twenty(20) percent of its outside diameter. The width of the trench shall not be greater than two(2) times the pipe diameter, to permit satisfactory jointing and thorough tamping of the bedding material specified in item 502 under and around the pipe. Recesses shall be excavated for any bells involved. Where rock or hardpan is encountered, the trench shall be excavated to a depth at least (30) centimeters below the grade established for the bottom of the pipe. This excess depth shall be refilled with approved material and thoroughly compacted.

Where in the opinion of the Engineer, the natural foundation soil is such as to require stabilization, such material shall be replaced by a layer of suitable material. Where an unsuitable material (peat, mulch, etc.) is encountered at or below invert elevation during excavation, the necessary subsurface exploration and analysis shall be made and corrective treatment shall be as directed by the Engineer.

501.4.2 Placing Pipe

The pipe shall be laid carefully, bell up-grade, ends fully and closely jointed, and true to the elevations and grades given. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. Each section shall be securely attached to the adjoining sections by the method specified for the type of joint used. All joints, unless otherwise specified, shall be filled with stiff mortar composed of one part Portland cement and two parts sand. The mortar shall be placed so as to form a durable, watertight joint around the whole circumference of the pipe. After each section of pipe is laid and before the succeeding section is laid the lower portion of the bell shall be plastered thoroughly on the inside with mortar to such depth as to bring the inner surface of the abutting pipe flush and even. After the section is laid, the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form

a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap. Any pipe, which is not true in alignment or which shows any undue settlement after being laid, or is damaged, shall be taken up and relaid or replaced without extra payment. All joints, including any connections, shall be capable of transferring the required shear across the point.

501.4.3 Backfilling

After the pipe has been installed and the mortar joints sufficiently set, granular material (sand) and / or selected material from roadway excavation or borrow shall be placed alongside the pipes in layers not exceeding twenty (20) cms in depth and compacted to minimum ninety (90) percent of the maximum dry density determined as per AASHTO T-191 Method, so that on each side of the pipe there shall be thoroughly compacted material at least as wide as the external diameter of the pipe except insofar as undisturbed material obtrudes upon this width. Each layer shall be moistened, if dry, and then compacted by tamping with mechanical hammers or by hand tamping with heavy iron tampers to the densities as specified under item 108.3.1 - Formation of Embankment with Common Material. This method of filling and compacting shall be continued until the embankment has reached an elevation of twenty (20) cms above the top of the pipe. When construction calls for placing a high embankment over the pipes, special instructions regarding the method of back filling shall be given by the Engineer.

501.4.4 Construction Plant

Movement of Construction equipment, over a culvert shall be at the contractor's risk. Any pipe injured thereby shall be repaired or placed at the contractor's cost.

501.5 Headwalls

Where indicated on the Drawings, the ends of the pipe culverts shall be protected by concrete or masonry headwalls constructed as shown on the Drawings. When headwalls are constructed, the ends of the pipe shall be neatly cutoff flush with the outside face of the headwalls.

501.6 MEASUREMENT AND PAYMENT

501.6.1 Measurement

The quantities to be paid for shall be the number of linear meters of pipe placed, completed and accepted.

Payment shall be made separately under Item 502 for furnishing and installing granular material or concrete in the bed of the culvert as shown on the Drawings.

501.6.2 Payment

The quantities, as measured above, shall be paid for at the contract unit price respectively, for each of the particular pay items listed below in the BOQ. Payment shall be full compensation for furnishing and placing all materials including mortar for joints, for excavating trenches and backfilling, and for all other costs necessary or usual to the proper completion of the work prescribed in this item. Headwalls, wing-walls and aprons together with the bedding for the concrete pipe culvert, will be measured and paid for separately.

Pay Item No.	Description	Unit of Measurement
501	Reinforced concrete pipe conforming to AASHTO M-170 class II complete in all respect as mentioned in Specification.	
	a) 310mm dia	LM
	b) 380mm dia	LM
	c) 460mm dia	LM
	d) 610mm dia	LM
	e) 760mm dia	LM
	f) 910mm dia	LM
	g) 1070mm dia	LM
	h) 1220mm dia	LM
	i) 1520mm dia	LM
	Reinforced concrete pipe conforming to AASHTO M-170 class IV complete in all respect as mentioned in Specification.	
	j) 310mm dia	LM
	k) 380mm dia	LM
	l) 460mm dia	LM
	m) 610mm dia	LM
	n) 760mm dia	LM
	o) 910mm dia	LM
	p) 1070mm dia	LM
	q) 1220mm dia	LM
	r) 1520mm dia	LM

SECTION 502 BEDDING OR ENCASEMENT OF CONCRETE PIPE CULVERTS

502.1 DESCRIPTION

This work shall consist of furnishing and placing granular material or concrete as specified in bedding and around concrete pipe culverts.

502.2 MATERIAL REQUIREMENTS

502.2.1 Granular Material

Granular material shall be sand or selected sandy soil all of which passes a 3/8 inch (9.5 mm) sieve and not more than fifteen (15) percent passes No. 200 sieve.

502.2.2 Concrete

Concrete Class B shall be as specified in Item 401.

502.3 CONSTRUCTION REQUIREMENTS

The bedding material as specified in Items 502.2.1 and 502.2.2 shall be laid to the dimensions shown on the drawings for the types specified or directed by the Engineer; the top surface of which shall be accurately shaped by template to fit the surface of the concrete pipe culvert for at least twenty (20) percent of its outside diameter.

Granular material shall be deposited in layers not exceeding twenty (20) cms and shall be compacted to at least Ninety-five (95) percent of maximum dry density in accordance with AASHTO T-180, Method D. However in case of sand, sand saturation method for compaction will be allowed, and density shall be approved by Relative Density Test Method vide ASTM-D 2049.

Concrete Class B shall be mixed, placed, finished and cured all in accordance with Item 401.

502.4 MEASUREMENT AND PAYMENT

502.4.1 Measurement

The quantities to be paid for shall be the number of cubic meters of granular material, or concrete Class B, placed and accepted.

502.4.2 Payment

Quantities measured as provided above shall be paid for at the contract unit price, for each of the particular pay items listed below, which prices and payment shall be full compensation for furnishing and placing all materials, labour, equipment, tools and incidental required for completion of the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
502 a	Granular material in bed to concrete pipe culvert	CM
502 b	Concrete 2500psi (175 kg/sm) in bedding and encasement of concrete pipe culvert	CM

SECTION 503 U N D E R D R A I N

503.1 DESCRIPTION

The work shall consist of furnishing and installing underdrains complete in accordance with these specifications and to the width shown on the typical cross-sections or drawings.

503.2 MATERIAL REQUIREMENTS

503.2.1 Perforated Concrete Pipe

This pipe shall conform to the requirements of AASHTO M 175 or to ASTM C 444 for the specified diameters and strength classes.

503.2.2 Porous Concrete Pipe

This pipe shall conform to the requirements of AASHTO M 176 for the specified diameters.

503.2.3 Granular Backfill

Granular backfill for bedding and surrounding underdrains shall be aggregate conforming to the requirements of Item 201.2 - Granular Sub-base, Grading C.

In order to avoid intrusion into the sub-base of the in place surrounding earth material, it shall be required that the ratio:

$$\frac{D_{15}\ \text{(Sub-base)}}{D_{85}\ \text{(Surrounding Earth)}}$$ shall be less than 5

503.3 CONSTRUCTION REQUIREMENTS

503.3.1 Trench and Bedding

Trenches shall be excavated to the width, line and grade as shown in the Drawings; Unless shown otherwise on the Drawings, the depth shall vary from 0.7 to 1.4 meters below the bottom of a gutter or ditch when underdrain is situated under a gutter or ditch, and to depths required for proper drainage, as determined by the Engineer. A bed of granular backfill, ten (10) cm thick, shall be spread, and compacted in the bottom of the trench throughout its entire length.

503.3.2 Placing Pipe and Backfilling

The pipe shall be embedded firmly in the bedding material, bells upgrade, ends fully entered in the adjacent bells and spot mortared to provide for centering of the pipe, but the joint shall not be closed to allow infiltration of water.

Perforated pipe shall be laid with the perforated length of the pipe on its underside.

After the pipe has been placed and approved by the Engineer, granular backfill as specified in Item 503.2.3 shall be placed around the drain for a thickness of at least thirty (30) cm and care shall be taken that no pipe is displaced. The upper portion of the trench shall then be filled with approved fine soil selected from structural, common or borrow excavation. All filling material shall be thoroughly compacted, to the satisfaction of the Engineer.

503.4 MEASUREMENT AND PAYMENT

503.4.1 Measurement

The quantities to be paid for shall be:

(1) The number of meters of underdrain, of the kind mentioned below, in place and accepted.

(2) The number of cubic meters of granular backfill, in place, and accepted.

503.4.2 Payment

The quantities, determined as provided above, shall be paid for at the contract unit price for the pay items listed below. These prices and payment shall be full compensation for furnishing and placing the underdrain, for excavating the trench in which the underdrain is laid, for granular backfill used, for the backfill and all other costs related to the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
503 a	Perforated Concrete Pipe for Underdrain, Diameter 150 mm	LM
503 b	Perforated Concrete Pipe for Underdrain, Diameter 200 mm	LM
503 c	Perforated Concrete Pipe for Underdrain, Diameter 380 mm	LM
503 d	Porous Concrete Pipe for Underdrain, Diameter 150 mm	LM
503 e	Porous Concrete Pipe for Underdrain, Diameter 200 mm	LM
503 f	Granular Backfill to Concrete Pipe Underdrain.	CM

SECTION 504 HEADWALLS, WING-WALLS, PARAPETS, APPROACH SLABS, APRONS AND SIPHON INLETS/OUTLETS

504.1 DESCRIPTION

This work shall consist of construction of sections as mentioned in the Items above in concrete, brickwork or stone work for concrete pipe and other culverts and bridges shown on the Drawings.

504.2 MATERIAL REQUIREMENTS

504.2.1 Formwork

Formwork shall be in accordance with the requirements of design or as directed by the Engineer.

504.2.2 Steel Reinforcement

Quality of Steel reinforcement shall be in accordance with the material requirements of Item 404.

504.2.3 Concrete

Quality requirements of all materials for Concrete of Class A, Class B, Class C, Class Y or lean concrete as specified on the Drawings and shall be in accordance with the material requirements of Item 401.

504.2.4 Brickwork

Quality of brick and other materials shall be in accordance with the requirements of Item 410.

504.2.5 Stone Work

Stone work shall be in conformity with item No. 412.

504.3 CONSTRUCTION REQUIREMENTS

504.3.1 Excavation

Excavation shall be in accordance with Item 107.3.1 and in conformity with the Drawings.

504.3.2 Granular Backfill

Granular backfill, if ordered in writing by the Engineer, shall be furnished, placed and compacted in accordance with Item 107.3.3.

504.3.3 Formwork

Formwork shall be supplied and fixed in the positions required for the concrete to be cast as shown on the Drawings and shall be erected and removed as directed by the Engineer.

504.3.4 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the Drawings. Furnishing, bending and fixing shall be in accordance with Item 404.

504.3.5 Concrete

Concrete Class A, B, C or Y shown on the Drawings shall be supplied, placed, finished and cured, as specified in Item 401.

504.3.6 Brickwork

Brickwork as shown on the drawings shall be supplied, placed and finished as specified in Item 410.

504.3.7 Stone Work

Stone work shall be constructed in conformity with item No. 412.

504.4 MEASUREMENT AND PAYMENT

504.4.1 Measurement

Excavation and Backfill shall be measured as specified in Item 107.

The formwork in place and accepted shall not be measured for payment and shall be deemed to have been paid under other items.

Steel reinforcement in place and accepted shall be measured as specified in Item 404.

Concrete in place and accepted shall be measured as specified in Item 401, as per concrete class specified.

Granular backfill in place and accepted shall be measured as specified in Item 107.

Brickwork in place and accepted shall be measured as specified in Item 410.

Stone work in place and accepted shall be measured as specified in item 412.

504.4.2 Payment

Excavation and Backfill shall be paid for under different Item of 107 as the case may be.

The formwork in place and accepted shall not be paid and shall be deemed to have been paid under other items.

Steel reinforcement in place and accepted shall be paid for as specified in Item 404.

Concrete in place and accepted shall be paid for as specified in Item 401, as per concrete class specified.

Granular backfill in place and accepted shall be paid for as specified in Item 107.

Brickwork in place and accepted shall be paid as specified in Item 410.

Stone work in place and accepted shall be paid as specified in item 412.

SECTION 505 M A N H O L E S

505.1 DESCRIPTION

The work shall consist of the furnishing and erecting pre-cast or cast in situ concrete manholes of sizes shown in drawings with the necessary frames and covers constructed in accordance with these specifications and the specifications for the other work items involved and in conformity with the dimensions, lines, elevations and design shown in the Drawings.

505.2 MATERIAL REQUIREMENTS

505.2.1 Precast Concrete Units.

These units shall be cast to the dimensions shown on the drawings. Structural concrete shall be Class-A in accordance with Item 401. Reinforcement shall be used as per design drawings. The precast units shall be cured in accordance with AASHTO M 170. Water absorption of individual cores taken from such units shall not exceed seven (7) percent.

A sufficient number of cylinders shall be cast to permit compression tests at seven (7) and twenty-eight (28) days, and to allow for at least two cylinders for each test. If the strength requirement is met at seven (7) days, the units will be certified for use fourteen (14) days from date to casting. If the strength requirements are not met at 28 days, all units made from that batch will be rejected.

Cracks in units, honeycombed or patched areas in excess of two hundred (200) square centimeter, excessive water absorption, and failure to meet strength requirements will be cause for rejection.

505.2.2 Steel Reinforcement

Steel reinforcement shall be in accordance with the requirements of Item 404.

505.2.3 Frames, Grates and Covers, and Ladder Rungs

Metal units shall conform to the dimensions shown on the Drawings and to the following requirements for the designated materials.

Gray iron castings shall conform to the requirements of AASHTO M 105. Strength class shall be optional unless otherwise specified.

Carbon steel casting shall conform to the requirements of AASHTO M 103. Grade shall be optional unless otherwise specified.

Structural steel shall conform to the requirements of AASHTO M 193 or ASTM A 283, Grade B or better.

Grey iron items shall conform to AASHTO M 105.

Galvanizing, where specified for these units, shall conform to the requirements of AASHTO M 111.

Malleable iron castings shall conform to the requirements of AASHTO M 106. Grade shall be optional unless otherwise specified.

505.2.4 Mortar

Mortar shall be composed of one part Portland cement and two parts of fine aggregate, by volume unless otherwise specified and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel. Aggregate for mortar shall conform to Item 401.2.2.

505.2.5 Concrete

In case of cast in situ concrete manholes, concrete shall be of Class A unless otherwise shown on the Drawings or as directed by the Engineer, and shall conform to the requirements prescribed for that particular class of concrete in Item 401. Forms of approved quality shall be used to give reasonable fair finish from inside, while rough form work may be allowed for outside finish. All other specifications shall be followed as per item 401.

505.3 CONSTRUCTION REQUIREMENTS

505.3.1 Excavation

Excavation shall conform to the requirements of Item 107.

505.3.2 Backfill

Backfill shall conform to the requirements of Item 108, unless where granular backfill as specified in Item 107 is required by the Drawings, or is specified in writing by the Engineer.

505.3.3 Concrete

Concrete construction shall conform to the requirements of Item 401.

505.3.4 Steel Reinforcement

Bending and fixing of steel shall conform to the requirements of Item 404.

505.3.5 Pre-cast Concrete Units

Pre-cast concrete units shall be erected in the positions shown on the Drawings, or as required by the Engineer.

During erection of the units outside of the manhole shall be finished smooth and the joints flushed full with mortar.

505.3.6 Connections

Sections of connection pipe shall be incorporated into the construction and placed at the elevation, direction and grade required. The inner ends of the pipe shall be flush with the inner faces of the walls.

505.3.7 Metal Frames

Metal frames shall be set on full mortar beds or otherwise secured as shown on the Drawings and the frames, covers, and gratings shall be accurately set true to the line and elevation required to fit the adjoining surface as approved by the Engineer.

505.3.8 Cleaning

Upon completion each manhole shall be thoroughly cleaned of any accumulation of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulations until final acceptance of the work.

505.4 MEASUREMENT AND PAYMENT

505.4.1 Measurement

The quantities to be paid for shall be:

(1) The number of concrete manholes, complete with frames and covers and all other relevant components, in position and accepted, from one (1) meter to two (2) meters deep;

(2) The number of concrete manholes, complete with frames and covers and all other relevant components, in position and accepted, more than two (2) meters and up to three (3) meters deep;

(3) The number of concrete manholes, complete with frames and covers and all other relevant components, in position and accepted, greater than 3 meter in depth.

In the determination of the depth of a manhole the distance shall be measured from the top surface of the manhole cover to the under surface of the foundation of the manhole.

505.4.2 Payment

The quantities measured as provided above shall be paid for at the contract unit price respectively, for each of the pay items listed below that is shown in the Bill of Quantities, which prices and payment shall be full compensation for furnishing and placing all materials, and for all other costs necessary or usual to the proper completion of the work prescribed in this item.

Excavation and backfill shall be measured and paid for as specified under Item 107 or 108, as the case may be.

Granular backfill, which is in place and accepted shall be measured and paid for as specified in Item 107.

Pay Item No.	Description	Unit of Measurement
505 a	Concrete Manhole 1 M to 2 M deep	NO
505 b	Concrete Manhole more than 2 M to 3 M deep.	NO
505 c	Concrete Manhole greater than 3 M deep.	NO

SECTION 506 DROP INLETS AND CATCH BASINS

506.1 DESCRIPTION

This work shall consist of constructing concrete catch basins, and drop inlets including the furnishing of metal frames, grates and lids, and the necessary excavation and backfill in accordance with these specifications and the specifications for other work items involved and in conformity with the dimensions, elevations and design shown on the Drawings.

506.2 MATERIAL REQUIREMENTS

506.2.1 Steel Frames, Grates and Lids

Steel frames, grates and lids shall conform to the requirements of AASHTO M-105.

506.2.2 Concrete

Concrete shall be as specified in Item 401, of the class indicated on the Drawings.

506.2.3 Masonry

When so indicated on the plans or approved by the Engineer, brick or concrete block masonry may be used in lieu of concrete for the walls of catch basins or drop inlets as specified in item 410, "Brick Masonry".

506.2.4 Steel Reinforcement

Quality of reinforcing steel if used in construction of catch basins shall be in accordance with the material requirements of item 404.

506.3 CONSTRUCTION REQUIREMENTS

506.3.1 Excavation and Backfill

Excavation and backfill shall conform to the requirements of Item 107 or 108 as the case may be.

506.3.2 Concrete Construction

Concrete of the specified class shall be supplied, placed finished and cured as specified in Item 401.

506.3.3 Connections

Inlet and outlet tile, sewer pipe and conduit for connections with such structures shall be of the same size, type and class as the tile, sewer pipe, and conduit with which connections are made and shall conform to the pertinent requirements therefor.

Pipe placed in concrete for inlet or outlet connections shall extend from the inside surface of the walls and beyond the outside surface of the walls a minimum distance of forty five (45) centimeters distance to allow for connections with conduits or sewers, and the concrete shall be carefully constructed around them so as to prevent leakage around their outer surface.

506.3.4 Frames, Grates and Lids

All frames shall be set on full mortar beds or otherwise secured as shown on the Drawings. Grates and lids shall be fitted or secured to the frames so that rocking or chattering will be eliminated.

The frames, grates and lids shall be accurately set so that the complete installation will be at the correct elevation required to fit the adjoining surface, the grates and lids shall not be in place while the adjoining concrete is struck-off and finished.

506.3.5 Cleaning

All catch basins and drop inlets shall be thoroughly cleaned of any accumulations of silt, debris, or foreign matter of any kind, and shall be kept clear of such accumulations until the final acceptance of the work.

506.4 MEASUREMENT AND PAYMENT

506.4.1 Measurement

The quantities to be measured shall be:

1) The number of drop inlets of the type specified in the construction of Drop inlets, complete in place and accepted.

2) The number of catch basins of the type specified, complete in place, and accepted.

506.4.2 Payment

The quantities measured as provided above shall be paid at the contract unit price for each of the pay items listed below. Such prices and payment shall be full compensation for furnishing and placing all materials, and for all other costs relative to the proper completion of the work prescribed.

Granular backfill in place and accepted shall be measured and paid for as specified in Item 107.

SECTION 507 G A B I O N S

507.1 DESCRIPTION

This work shall consist of wire-mesh gabions, furnished and placed in accordance with these specifications, and the specifications for the other work items involved, and at the locations and in conformity with the lines and grades shown on the Drawings. The work in general, covers gabions used for river and stream stabilization work, such as bank revetments, jetties, groins deflectors, scour protection and retaining structures.

507.2 MATERIAL REQUIREMENTS

507.2.1 General

Gabions shall be enclosed by galvanized steel wire mesh, which shall be supplied folded flat to facilitate transport and handling.

Gabions shall be furnished in accordance with the various lengths, widths and heights required by the Drawings, or as directed by the Engineer. If not otherwise required, all gabions shall be one meter in width. The lengths shall be multiples of 2, 3 or 4 times the width of the gabion and heights shall be three tenth (0.3), one half (0.5) or one (1) meter.

507.2.2 Wire

All wire shall be a good commercial quality of steel and size as per Drawings coated with a prime western speller or equal (AASHTO M 120) applied at a rate of not less than 0.8 ounces per square foot (0.25 Kg/Sq. M) of uncoated wire.

Uniformity of coating shall withstand ten (10) one-minute dips by the Preece Test in accordance with AASHTO T-66. “Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc Coated (Galvanized) Iron or Steel Articles”. Wire mesh shall withstand 220 hours of exposure before failure by rusting of any part when subjected to a salt spray test in accordance with ASTM B 117.

The tensile strength of the wire shall be in the range of four thousand (4,000) to six thousand (6000) kg. / sq. cm. and shall have an elasticity to permit elongation of the mesh equivalent to a minimum of ten (10) % without reducing the gauge or tensile strength of the wire.

The minimum size of the wire used in fabrication of the gabion baskets shall be as follows:-

	Diameter (mm) inch	**US Steel Wire Gauge**
Body Wire	(2.3) 0.09”	11
Selvedge or Perimeter Wire	(2.8) 0.11”	9
Tying and Connecting Wire	(1.95) 0.07”	13

507.2.3 Fabrication

Gabions shall be in the form of rectangular baskets of the required dimensions and shall be manufactured from wire as specified above. Gabions shall be made of steel wire triple twisted forming a uniform hexagonal mesh pattern with openings eight (8) cm by ten (10) cm or by twelve (12) cm. The edges shall be formed into securely connected selvedges adequate to prevent raveling. Individual basket ties and connections shall be made by using a quantity of wire not less than 8 percent of the weight of each basket.

When the gabion length exceeds its width, it shall have securely tied diaphragms connected at all edges to form individual cells of equal length and width. Diaphragms shall be of the same material and manufacture as specified above for the gabions.

Four cross-connecting wires shall be provided in each cell having a height of one half the width or less, and eight (8) cross-connecting wires shall be provided in each cell having a height greater than one half the width.

All the characteristics, values and figures given in the above specifications are subject to the tolerance of plus or minus five (5) percent.

507.2.4 Rock Fill

Fill for gabions shall consist of hard, durable rock pieces that will not deteriorate when submerged in water or exposed to severe weather conditions. Rock pieces shall be generally uniformly graded in sizes ranging from ten (10) cm to twenty (20) cm. Filled gabions shall have a minimum density of one thousand three hundred sixty (1,360) kg per cubic meter. Void spaces shall be evenly distributed and shall not exceed a maximum of thirty (30) percent.

The rock shall meet the requirements of AASHTO M 63 except that the Sodium Sulphate Soundness Loss shall not exceed nine (9) % after five (5) cycles.

507.3 CONSTRUCTION REQUIREMENTS

Installation shall be performed in a workmanlike manner as approved by the Engineer. Beds for gabions shall be suitably level. Gabions forming elements of structures shall be securely connected along the complete length of top contact edges by means of the above specified tying and connecting wire.

Before the rock fill is placed the gabions shall be stretched in such manner as will permit proper shape, alignment and compaction of fill.

Rock fill for exposed faces of gabions walls shall be carefully selected for uniformity or size, and the pieces shall be hand placed to provide a neat appearance as approved by the Engineer.

The vertical joints of gabion baskets shall be staggered as in running bond brickwork.

507.4 MEASUREMENT AND PAYMENT

507.4.1 Measurement

The quantities shall be measured for payment as below:

i) Wire Mesh

The galvanized steel wire mesh furnished placed and accepted shall be the theoretical number of kilograms calculated from the weight per square meter of mesh certified by the manufacturer and approved by the Engineer. The area of mesh to be measured shall be the net area of the Gabion in position.

ii) Rock Fill

The rock fill shall be the number of loose cubic meters of rock placed in the gabion with an allowance of maximum thirty (30) % voids and accepted and measured by the width, breadth and length of the gabion constructed.

507.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price, which shall be full compensation for all necessary excavation, furnishing and placing of materials and all other costs related to completion of the work.

Pay Item No.	Description	Unit of Measurement
507 a	Steel wire mesh with double twist for Gabions including its weaving as per design and size.	KG
507 b	Rock fill in Gabions	CM

SECTION 508 BRICK PAVING

508.1 DESCRIPTION

This item shall consist of one or more layers of bricks laid over thin layer of spread sand and the joints filled with sand with suitable bonding, over prepared shoulder or embankment slopes.

508.2 MATERIAL REQUIREMENTS

508.2.1 Bricks

Quality of bricks shall meet the Material Requirements as specified in Item 410 or as approved by the Engineer.

508.2.2 Sand

Sand used in this work for bed or joints shall be medium to fine sand.

508.3 CONSTRUCTION REQUIREMENTS

508.3.1 Shoulder

The shoulders shall be properly leveled as directed by the Engineer before commencement of work on this item.

508.3.2 Embankment Slopes

These shall be cut and dressed to dense slopes according to specified line and grade as per Item 108, or as directed by the Engineer before commencement of this item.

508.3.3 Stacking of Bricks

The bricks shall be delivered at site in stacks of ten courses high and two bricks thick for the convenience of proper inspection.

508.3.4 Placing of Bricks

A thin layer of sand, at least 1" (25 mm) in thickness, shall be spread over dressed shoulder or slope to facilitate neat dressing of bricks. The bricks shall be laid closely packed in parallel rows transverse to the center line and/or as directed by the Engineer at site. The bricks shall be laid on edge, in one (1) or two (2) courses as called for in the plans. If more than one (1) course is to be laid the joints in the successive courses will be staggered. Each course shall be properly rolled and joints filled with sand or approved local soil before laying the next course.

508.4 MEASUREMENT AND PAYMENT

508.4.1 Measurement

Brick paving when laid and finished to the required thickness and grade line shall be measured by in superficial area. The unit of measurement will be square meter.

508.4.2 Payment

Payment shall be made as measured above and shall be full compensation for preparing and shaping the shoulders and embankment slopes, replacement of unstable material, provision and laying of the sand bed and bricks, filling the voids with sand or approved local soil, watering and rolling the whole width for proper compaction, also including material, labour, equipment, tools, and incidentals necessary to complete the work prescribed in this Item.

Pay Item No.	Description	Unit of Measurement
508 a	Brick paving (Single course)	SM
508 b	Brick paving (Double course)	SM

SECTION 509 RIPRAP AND REINFORCED CONCRETE SLOPE PROTECTION

509.1 DESCRIPTION

This work consists of furnishing and placing a protective covering of erosion resistant material as riprap or reinforced concrete slope protection on the locations shown on the plans for slopes or pier foundation protection. The work shall be done in accordance with the specifications and conformity with the lines, grades, thickness and typical cross-sections shown on the plans.

The areas to receive riprap or slope protection of any kind shall be dressed smooth to the slopes or shapes called for on the plans and shall be free from stumps, organic matter, or waste material. A filter blanket and/or geotextile should be provided where it is anticipated that there may be migration of fines through the riprap. Toe trench and/or filter blanket is to be constructed, as directed by the Engineer.

All materials, regardless of type or kind, shall be placed as per lines and levels called for on the Drawings.

509.2 MATERIAL REQUIREMENTS

509.2.1 Stones

Stone for riprap shall consist of field stone or rough un-hewn quarry stone as nearly rectangular in section as is practical, except that riprap of Class A shall consist of round natural stones. The stones shall be sound, tough, durable, dense, resistant to the action of air and water, and suitable in all respects for the purpose intended. Samples of the stone to be used shall be submitted to and approved by the Engineer before any stone is placed. The minimum apparent specific gravity shall be two and a half (2.5) and water absorption shall not exceed six (6) percent for stones to be used in riprap. The stone shall not have an abrasion loss greater than forty five (45) percent when subjected to five hundred (500) revolutions in a Loss Angeles Abrasion test.

Stones for riprap shall be one of the following classes as shown on the Drawings or determined by the Engineer:

Class A: Stones ranging in weight from a minimum of fifteen (15) Kg to a maximum of twenty five (25) Kg, with at least 50 percent by weight of the stones weighing more than twenty (20) kg.

Class B: Stones ranging in weight from a minimum of thirty (30) kg to a maximum of seventy (70) kg, with at least fifty (50) percent by weight of the stones weighing more than fifty (50) kg.

Class C: Stones ranging in weight from a minimum sixty (60) kg to a maximum of one hundred (100) kg, with at least 50 percent by weight of the stones weighing more than eighty (80) kg.

Class D: Stones ranging in weight from a minimum hundred (100) kg to a maximum of one hundred and fifty (150) kg, with at least 50 percent by weight of the stones weighing more than one hundred and twenty five (125) kg.
Sound pieces of broken concrete obtained from the removal of bridges culverts, and other structures may be substituted for stone upon approval by the Engineer.

509.2.2 Filter Material

The grading of the filter material shall be as specified on the drawings or in the Special Provisions. If not otherwise specified, it will be required that D15 of the filter is at least 4 times as large as D15 for the underlying embankment materials, and not more than 4 times the D85 for the embankment material.

Where: D15 and D85 are the particle diameters corresponding to fifteen (15) percent and eighty five (85) percent respectively, passing (by weight) in a grain size analysis.

If filter geotextile material is used, it shall be thermally bonded, water permeable nonwoven 100% continuous polypropylene filaments with combination of high initial modulus and high elongation. Geotextile shall be resistant to rotting, moisture and chemical attack.

Filter geotextile shall be thin and pre-compressed, with hydraulic properties not affected by load compression. Opening size shall have wide range of pore sizes and shapes. Geotextile shall be low weight and shall be able to withstand installation stresses. Filter geotextile shall have dimensional stability for pore size and permeability and shall conform to ASTM and EN ISO standards (see Item 215). It shall be durable and have predictable life of 100 years in all types of natural soils. It shall conform to oxidation resistance as per EN ISO 13438.

509.2.3 Portland Cement

Portland cement shall conform to the requirements of AASHTO M 85.

509.2.4 Fine Aggregates

Fine aggregates for mortar shall conform to the requirements of AASHTO M 45.

509.2.5 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the drawings. Furnishing, bending and fixing shall be in accordance with Item 404.

509.2.6 Concrete

Concrete of specified Class shown on the Drawings shall be supplied, placed, finished and used as indicated in item 401.

509.2.7 Water

Water for concrete and mortar of ratio 1:3 shall conform to Item 401.2.7.

509.3 CONSTRUCTION REQUIREMENTS

509.3.1 Excavation

The bed for the riprap shall be excavated to the required depths and compacted, trimmed and shaped to the entire satisfaction of the Engineer or as shown on the plans.

The riprap shall be set in a toe trench as shown on the Drawings. The toe trench shall be filled with stone of the same class as the one specified for the riprap, unless otherwise specified. All toe trenches and excavations shall be approved by the Engineer with firm sub-grade or base prior to placement of stones. Stones shall be placed so as to provide minimum of voids. Larger stones shall be placed in the toe trench and on the outside surface of the slope.

509.3.2 Placing

Stones placed below water line shall be distributed so that the minimum thickness of the riprap is not less than that specified.

Stones above the water line shall be placed by hand. They shall be laid with close, broken joints and shall be firmly bedded into the slope and against the adjoining stones. The stones shall be laid perpendicular to the slope with ends in contact. The riprap shall be thoroughly compacted as construction progresses and the finished surface shall present an even, tight surface. Interstices between stones shall be chinked with spalls firmly rammed into place.

Unless otherwise provided, riprap shall have the following minimum thickness, measured perpendicular to the slope:

Class A:	20 cm
Class B:	45 cm
Class C:	60 cm
Class D:	75 cm

The surface of riprap placed above the water line shall not vary from the theoretical surface by more than 8 cm at any point.

For placement of geotextile, area shall be graded, debris shall be removed and slope shall be compacted for smooth surface. For slopes over 8-meter, geotextile shall be placed in full width length from slope top to bottom. Overlap shall be in the direction of water flow. Ditches shall be excavated for anchoring geotextile at top and toe of the slope. 75 to 150 mm sand or gravel bedding layer shall be placed prior to installation of riprap to allow continuous contact between geotextile and subgrade.

509.3.3 Loose Riprap

The loose riprap shall be placed in layers manually or other methods approved by the Engineer, all to secure a stable mass. Surface irregularities of the slope shall not vary more than eight (8) centimeters along the intended slope. After the completion and approval of the riprap placement, the surface voids of the riprap in the footing trench and on the lower portions of the slope shall be filled with excavated material and dressed to the satisfaction of the Engineer.

509.3.4 Grouted Riprap

Stone for this purpose shall, as for as practicable, be selected of the size and shape so as to secure fairly large, flat-surfaced stone which will lay up with a true and even surface and a minimum of voids. The stones shall be placed first and roughly arranged in close contact, the larger stones being placed near the base of the slope. The spaces between the larger stones shall be filled with stones of suitable size, leaving the surface smooth, reasonably tight, and conforming to the contour required. In general, the stone shall be laid with a degree of care that will ensure for plane surfaces a maximum variation from a true plane of not more than three (3) percent. Warped and curved surfaces shall have the same general degree of accuracy as specified above for plane surface.

As each of the larger stones is placed, it shall be surrounded by fresh mortar and adjacent stones shall be shoved into contact. After the larger stones are in place, all of the spaces or openings between them shall be filled with grout consisting of one (1) part of Portland Cement and three (3) parts of fine aggregates, and one-fifth (1/5) part of hydrated lime with sufficient water to produce a plastic mix and the smaller stones then placed by shoving them into position, forcing excess mortar to the surface, and ensuring that each stone is carefully and firmly bedded laterally. Mortar shall not be placed in temperature lower than five (5) degree C. During hot, dry weather the work shall be protected from the sun and kept moist for a minimum of 3 days after placement. Stones shall be kept wet during placing of the mortar.

After the work has been completed as above described, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints shall then be roughly pointed up either with flush joints or with shallow, smooth raked joints.

Weep holes shall be provided through the riprap cover as shown on the plans or as directed by the Engineer.

509.3.5 Reinforced concrete slope protection

The slopes with suitable material shall be prepared with appropriate compaction to form a sub-grade approved by the Engineer and formwork shall be completed accordingly.

After furnishing and fixing the steel reinforcement, reinforced concrete slope protection shall be constructed after light spray of water at the locations shown on the plans or where directed by the Engineer. Placing and finishing of concrete shall conform to the requirements specified in Item 401.

509.4 MEASUREMENT AND PAYMENT

509.4.1 Measurement

The quantities to be measured for payment shall be the number of cubic meters of completed and accepted work placed to the designated thickness on slopes including the toe-wall as shown on Drawings.

A filter layer of granular material, when required, shall be measured separately by the cubic-meters, in place and accepted.

The computation of the quantities will be based on the volume within the theoretical limiting dimensions designated on the Drawings.

These items shall include the furnishing of all material, placing and grouting stone riprap, mixing and placing concrete including reinforcement. Excavation, backfilling and slope preparation shall not be measured for payment but will be considered subsidiary to the items of "Riprap" or "Slope Protection".

509.4.2 Payment

The quantities, measured as provided above shall be paid for at the contract unit price, for each of the pay items listed below and shown in the Bill of Quantities. Payment shall be full compensation for furnishing all materials, labour, equipment, tools supplies and all other costs related to completion of the work.

Pay Item No.	Description	Unit of Measurement
509 a	Riprap, Class A	CM
509 b	Riprap, Class B	CM
509 c	Riprap, Class C	CM
509 d	Riprap, Class D	CM
509 e	Grouted riprap, Class A	CM
509 f	Grouted riprap, Class B	CM
509 g	Grouted riprap, Class C	CM
509 h	Grouted riprap, Class D	CM
509 i	Reinforced concrete slope protection 20cm thick 300 Psi (210kg/cm^2) (excluding reinforcement).	CM
509 j	Filter layer of Granular Material	CM
509 k	Filter layer of Geotextile Material	SM

SECTION 510 DISMANTLING OF STRUCTURES AND OBSTRUCTIONS

510.1 DESCRIPTION

This work shall consist of dismantling, removal, wholly or in part and satisfactory disposal of broken material from buildings, fences, bridges, culverts, drainage facilities at different locations and any other obstructions which are not designated or permitted to remain on those sections of existing highways except for the obstructions to be removed and disposed of under other items in the contract. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, pits and ditches.

510.2 CONSTRUCTION REQUIREMENTS

General

Engineer shall specify the extent of dismantling for each structure and the contractor shall raze, remove and dispose of all remains of all those dismantled structures and other obstructions any portion of which are on the right of way, except utilities and those for which other provisions have been made for removal. All designated useable material shall be removed, without unnecessary damage, in sections or pieces, which may be readily transported, and shall be stored by the contractor at specified places with in the project limits. Unusable perishable material shall be destroyed. Non-perishable material may be disposed of outside the limits of view from the project with written permissions of the property owner on whose property the material is placed. Copies of all agreements with property owners are to be furnished to the Engineer. Basements or cavities left by structural removal shall be filled to the level of the surrounding ground and, if within the prism of construction shall be compacted to the required degree of compaction designated on the plans for roadway embankment and as specified in Item 108.3.1.

Salvaged pipe culverts or other structures shall be stored at designated and accessible points on the project as approved by the Engineer and shall be the property of the client. Dismantling shall be carried out either manually or with approved equipments. Structures to be dismantled may include plain or reinforced concrete, brick, stone masonry or any other such construction item.

510.2.1 Removal of Bridges, Culverts and other Drainage Structures

Concrete Bridges, culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic. Unless otherwise directed, the sub-structures of existing structures shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed thirty (30) centimeters below ground surface. Where such portions of existing structures are wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure. Steel bridges and wood bridges as designated on the plans, shall be carefully dismantled without unnecessary damage. Steel members shall be match marked, unless such match marking is waived by the Engineer. All salvaged material shall be stored as previously specified.

Blasting or other operations necessary for the removal or dismantling of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work.

510.2.2 Removal of Pipes

Unless otherwise directed all pipes shall be carefully removed and every precaution taken to avoid breaking or damaging the pipe. The contractor shall be held responsible for the satisfactory removal of such structures in a usable condition. In case these provisions are violated, due to the Contractor's negligence, all material to be salvaged which is damaged in dismantling / removal to impair its future use will be charged to the contractor at sixty (60) percent of the current quoted price, delivered to the project, of an equal amount of new material. This amount of money shall be deducted from any money due or to become due to contractor.

510.2.3 Fences, Boulders, Stone Piles

Stones, fences, piles of stones or boulders of size greater than one-quarter (1/4) cubic meter in volume which lie within the limits of the work as shown on the plans, or which fall within the approved cross sections shall be removed and disposed of as directed.

When fences enclosing pasture land or farm land are to be removed, the Contractor shall notify the property owner sufficiently in advance to permit the owner reasonable time to construct supplemental fences or make other arrangements.

510.2.4 Wells

Existing wells, abandoned or active, which lie within the limits of the Work as shown on the plans, or which fall within the approved cross sections or as directed by the Engineer shall be dismantled, backfilled and compacted. The Contractor shall carefully remove all salvageable material and store it at a location on site designated by the Engineer. Unless otherwise noted or directed, all salvageable material shall become the property of the Client. Wells shall be filled to the level of the surrounding ground and, if within the prism of construction, shall be compacted to the type of compaction within the moisture range designated on the plans for roadway embankment and as specified in Item 107. No dismantling or backfilling of a well shall be done by the Contractor without the prior approval of the Engineer.

No separate payment for dismantling or backfilling wells shall be made, the costs being considered subsidiary to other items listed in the Bill of Quantities, except that the compacted backfill required for wells will be paid for as per applicable item of backfill material.

510.3 MEASUREMENT AND PAYMENT

510.3.1 Measurement

The quantity of dismantling the structure to be paid for shall be measured in cubic meter or Tons of structure dismantled. All such measurements shall be agreed by the Engineer and the Contractor before the dismantling work starts. Necessary shop drawings will be prepared by the contractor for such purpose.

510.3.2 Payment

The quantity as measured above shall be paid for at the Contract price per cubic meter or Tons. The payment shall constitute full compensation for dismantling, removal and disposal of material as directed by the Engineer and for all labour, equipments, tools and incidentals necessary to complete the work

Pay Item No.	Description	Unit of Measurement
510 a	Dismantling of Structures and Obstructers	CM

SECTION 511 STONE PITCHING

511.1 DESCRIPTION

Where shown on the Drawings, this work shall consist of furnishing hand-set pitching laid dry or grouted to stabilize slopes or as a protection against water or other erosion to form a flat or cured surface as directed by the Engineer. All materials regardless of type or kind shall be placed as per the lines and levels called for on the plans.

511.2 MATERIAL REQUIREMENTS

511.2.1 Stones

The stones shall comprise good, hard and durable broken boulders or pieces of rock. These shall be sound, dense, resistant to the action of air and water and suitable in all respects for the purpose intended. Stones of class I or II shall be used in pitching, shall conform to the following specifications. The depth of the stones and their weight shall be as under:

Class I

Stones ranging in weight from a minimum of fifteen (15) Kg to a maximum of twenty five (25) Kg with at least fifty (50) percent by weight of the stones weighing more than twenty (20) Kg. The depth of the stones shall generally be from twenty (20) cm to twenty five (25) cm and shall be used for heavy pitching to culvert or bridge ends and approaches, Wadi diversions, protection for structures, revetment to slopes and where directed.

Class II

Stones ranging in weight from a minimum of ten (10) Kg to a maximum of fifteen (15) Kg with at least fifty (50) percent by weight of the stones weighing more than twelve (12) Kg. The depth of the stones shall vary from fifteen (15) cm to twenty (20) cm and shall be used for lighter pitching where directed to ditches, beams, dykes etc.

511.2.2 Portland Cement

Portland cement shall conform to the requirements of AASHTO M 85.

511.2.3 Fine Aggregates

- Sand for Cement Mortar shall be Coarse Sand conforming to AASHTO M-45.
- Sand for Bitumen mixture shall be fine, clean and pure sand conforming to AASHTO M-45.

511.2.4 Bitumen

Bitumen shall be of Penetration Grade 80/100 conforming to AASHTO M-20

511.2.5 Water

Water for cement sand mortar shall be as specified in Item 401.

511.3 CONSTRUCTION REQUIREMENTS

511.3.1 Dry Pitching

1. The bed upon which pitching shall be laid, shall be firm or compacted of approved granular material of specified thickness and to the required grades and lines as shown on the plans or as directed and approved by the Engineer.
2. The stones shall comprise roughly dressed and shaped, set on their edges with their longest dimension at right angles to the flow of water. These shall be securely bedded, breaking bond closely packed with any interstices locked and filled by selected stone spalls hammered in.
3. The loose pitching specified in plans shall be placed by dumping and spreading in layers by hand or other methods approved by the Engineer all to secure a stable mass.
4. The ends of pitched areas shall be protected from undermining by the use of edge stones at least twice the general size and weight set on end.
5. In large or slope areas of pitching, key stones shall be provided at the rate of one per square meter, at least one and a half times the general size and weight, set on end.
6. The pitching to the batters of the earth works and diversions of waterways shall be carried down in trench to such a depth as will ensure a sound footing for the lowest course. Subsequent to pitching the trench shall be backfilled to normal ground level with approved, well compacted suitable material.

511.3.2 Grouted Pitching with Bitumen Joints

1. Slope shall be dressed and compacted to give a smooth and stable surface for further construction activity to be carried out over it. The surfaces of the rock shall be cleaned of adhering dirt and clay and shall be moistened
2. Slope shall be divided into panels of roughly 2m x 2m size by full depth straight wooden (or any other suitable material) fillets 2cm thick. Pitching shall be furnished in panels with weep holes. The precise dimensions of panels in any instance and the spacing of the weep holes shall be as required by the Engineer.
3. Stone in the bottom courses and to a vertical height and thickness as per plans shall be carefully arranged by hand to inter lock and so as to yield true and even surface with minimum voids and conforming to the contour required.
4. Water shall be sprinkled over the dressed and compacted earth-work surface, before cement - sand mortar is spread over it.
5. A layer of Cement - Sand (1:3) Mortar approximately 20mm thick, or as specified in the drawings, shall be laid within panels over the dressed and compacted soil, concurrently followed by next operation of stone work, when the mortar is still soft, to provide the stones a bedding.
6. Stones shall be placed over the mortar bed, starting with heaviest stones at the bottom and lighter stones at the top. The stones shall be arranged so as to form stable interlocking arrangement, such that voids between stones are kept to a minimum.
7. Voids between stones shall be grouted with Cement – Sand (1:3) Mortar such that the exposed surface of stones projects between 4cm to 8cm above the grout.
8. Curing shall be carried out for a minimum period of 4 days and after expiration of the curing period, the exposed surfaces shall be cleared of all curing mediums
9. Wooden fillets installed earlier, to make panels, shall be removed after completion of curing period or when in the opinion of the Engineer, cement mortar and grout has attained sufficient strength to keep the stones in place. The cavities so formed after removal of fillets shall be caulked to full depth with Bitumen – Sand (1:2) mixture to fully seal any voids, so that water shall not penetrate to the bottom.

511.3.3 Grouted Pitching in PCC Panels

Grouted Stones pitching in PCC panels shall be provided where high embankments are encountered or where more stability is required. It shall be carried out in similar manner to Item 511.3.2, except that Bitumen Joints shall not be formed but rather stone pitching shall be bound by PCC panels on all sides. Stone pitching shall be carried out as per drawings and instructions of the Engineer.

511.4 MEASUREMENT AND PAYMENT

511.4.1 Measurement

The quantities shall be measured by the square meter of completed and accepted work placed to the designated thickness of slopes including the toe walls as shown on Drawing. Toe walls shall be measured by the height times the length, and no additional payment will be made for the additional thickness of the toe walls when compared to the slope thickness. Measurement shall be based on the dimensions shown on the plans or as otherwise authorised by the Engineer. These items shall include the furnishing of all material, placing and grouting stone pitching. Excavation, backfilling and slope preparation shall not be measured for payment, but will be considered subsidiary to the item of "Stone Pitching".

511.4.2 Payment

The amount of completed and accepted work as measured above shall be paid for at the contract unit price for each of the pay items listed below and specified in the Bill of Quantities, which price shall be full compensation for furnishing all materials, for all labour, equipment, tools, supplies, and all other item necessary for the completion of the work. Concrete for PCC panels shall be paid separately under relevant item of work.

Pay Item No.	Description	Unit of Measurement
511 a	Providing and laying dry stone pitching with un coursed rubble (15-20cm thick) for any purpose.	SM
511 b	Providing and laying grouted stone pitching with un coursed rubble (15-20cm thick) for any purpose.	SM
511 c	Grouted stone pitching (20-25cm thick) with bitumen joints	SM
511 d	Grouted stone pitching (15-20cm thick) with PCC bands (paid separately) without bitumen joints	SM
511 e	Grouted stone pitching (20-25cm thick) with PCC bands (paid separately) without bitumen joints	SM

SECTION 512 DITCH LINING AND WASH CHECKS

512.1 DESCRIPTION

This work shall consist of the construction of stone or concrete ditch and/or wash checks, in accordance with the specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

512.2 MATERIAL REQUIREMENTS

Material shall conform to the requirements specified in the following items.

512.2.1 Concrete

Concrete for ditch lining and wash checks shall be as specified in item 401.

512.2.2 Reinforcing Steel

Reinforcing steel shall be as specified in Item 404.

512.2.3 Stone and Mortar

Stone and mortar for grouted stone ditch lining or grouted stone wash checks, shall be as specified in Item 509 for Riprap and reinforced concrete slope protection.

512.3 CONSTRUCTION REQUIREMENTS

512.3.1 Excavation

The sub-grade for the ditch lining or wash checks shall be excavated to a smooth surface parallel to the proposed finished surface and to a depth sufficient for the full thickness of the lining or wash checks as shown on the drawings. Unstable sub-grade material shall be removed and replaced with suitable materials as approved by the Engineer.

512.3.2 Concrete Ditch Lining and Wash checks

Concrete ditch lining and wash checks shall be constructed of Class A concrete. The composition, consistency, proportioning, mixing, and protection of the concrete shall conform to the requirements of item 401. Placement of concrete for ditch lining shall begin at the lower end of the portion of the ditch to be lined and progress toward the upper end.

If shown on the plans, the concrete shall be reinforced with the type of reinforcement and in the manner indicated. Contraction or construction joints shall be spaced and formed as indicated in the plans.

The surface shall be finished with a wooden float. Bridges for Workmen shall be used to avoid walking in the freshly laid concrete.

Immediately after the finishing operations are completed, the concrete shall be protected and cured in a manner as approved by the Engineer.

512.3.3 Stone Ditch Lining and Stone Wash Checks

a. Stone Ditch Lining

The stones shall be placed in rows transversely to the centerline of the ditch in the manner indicated on the plans. The stones shall be placed with ends and sides abutting and the joints between stones in each row breaking with the joints in the preceding row. The larger spaces between stones shall be filled with spalls. The stones shall be rammed or compacted to give them firm bearing and stability.

b. Stone Wash Checks

The stones for wash checks shall be laid to form a structure of the dimensions shown on the plans. The sides and ends of the stones shall be in contacts much as the sizes and shapes of the stones will permit. Spalls shall be rammed into the larger spaces between stones to form a solid wall. Joints between stones in one row shall break with joints between stones in the adjacent rows.

Stone wash checks may be substituted with concrete wash checks, constructed by class A concrete, if approved by the Engineer at no extra cost to the contractor or client.

c. Grout

After the surface has been inspected and approved, the spaces between stones shall be completely filled with a grout composed of one (1) part of Portland Cement and three (3) parts of fine aggregate mixed with sufficient water to produce a plastic mortar. The grout shall be brushed or broomed into the spaces to ensure proper filling.

The grout shall be cured in the manner as provided for "Grouted Riprap" in Item 509, "Riprap and Reinforced Concrete Slope Protection."

512.4 MEASUREMENT AND PAYMENT

512.4.1 Measurement

a. Ditch Lining

Ditch lining shall be measured in square meter by multiplying the exposed face width to the length of ditch and accepted in place as measured along the finished surface as shown in the plans or authorized by the Engineer.

b. Wash Checks

Wash checks shall be measured according to the linear meter of wash checks complete and accepted in place. Measurement shall be made perpendicular to the ditch centerline along the top surface and at the upstream edge of each wash check.

512.4.2 Payment

a. Ditch Lining

The amount of completed and accepted Work as measured, will be paid for at the unit price(s) bid per square meter as specified in the Bill of Quantities for "Concrete Ditch Lining" or "Grouted Stone Ditch Lining" which price(s) shall be full compensation for furnishing, transporting, and placing all materials, including reinforcement, if required, for all excavation, backfilling and for all labor, tools, and all other items necessary for the proper completion of the Work.

b. Wash Checks

The amount of completed and accepted Work as measured will be paid for at the unit price(s) bid per linear meter as specified in the Bill of Quantities for "Concrete Wash Checks" and "Grouted Stone Wash Checks," which price(s) shall be full compensation for all excavation, backfilling, for all materials, for all labor, equipment, tools and all other items necessary for the proper completion of the Work.

ANCILLARY WORKS

ANCILLARY WORKS

SECTION 600 G E N E R A L

This section shall consist of items of work which are ancillary or incidental to the other parts of the General Specifications. Such works shall include general items, precast concrete posts and markers, traffic control devices, side walks, guard rails, detours, traffic signs, pavement marking, reflectors, fencing and brick edging etc., in accordance with these specifications and in conformity with the lines, grades sections dimensions and locations in the plans or as required by the Engineer.

This section deals with those items of work in which small elements of construction employ construction items such as concrete, brick work, stone masonry, steel reinforcement or structural steel. These items of work have been separately quantified so that contractor can price them by assessing size of each element and extra effort which is essential in addition to the specification requirement of the parent item.

Metal guard-rails, traffic road signs and safety devices, pavement markings, reflectorised pavement studs, and other such fixtures shall meet the requirements of ISO - 9,000 for which certificates of manufacturers and supplies shall be produced.

SECTION 601 CONCRETE KERBS, GUTTERS AND CHANNELS

601.1 DESCRIPTION

This work shall consist of kerb, gutter, channel, or combination of kerb and gutter or channel; constructed of the following materials and in accordance with the specifications at the location and of the form, dimensions and designs shown on the Drawings or as directed by the Engineer. The kerb, gutter, channel or in combination may be constructed by one of the following methods.

i) Cast in place concrete kerbing.
ii) Precast concrete kerbing.
iii) Extruded concrete kerbing.

601.2 MATERIAL REQUIREMENTS

The concrete for cast in place concrete kerbs, gutters and channels shall be either Class 'A' or class 'C' or as indicated on the Drawings and shall conform to the requirements of that particular class prescribed under item 401.1.1. “Classes of concrete”. An air entraining agent, if required, shall be added during mixing an amount to produce five (5) to eight (8) percent air by volume in the mixed concrete.

Precast concrete kerbing units shall consist of class 'C' concrete conforming to the requirement of item 401 and to lengths, shape and other details shown on the Drawings. Kerbing which shows surface irregularities of more than five (5) mm when checked with three meter straight edge or surface pits more than fifteen (15) mm in diameter will be rejected.

Forms to hold the concrete shall be built and set in place as described under item 403-Formwork.

Forms for at least sixty meters of kerb or combination of kerb and gutter or channels shall be in place and checked for alignment and grade before concrete is placed. Curved sections shall have forms of either wood or metal and shall be accurately shaped to radius of curvature shown on the Drawings. Steel Reinforcement if required shall conform to item 404 "Steel Reinforcement".

Expansion joint filler shall be either the performed type conforming to requirement of AASHTO-M 153 or shall be precast fiber board packing.

Joint filler shall consist of one part cement and two parts of approved sand with sufficient quantity of water necessary to obtain the required consistency. The mortar shall be used within thirty (30) minutes after preparation.

The Bonding compound when used shall conform to AASHTO M-200.

601.3 CONSTRUCTION REQUIREMENTS

601.3.1 Cast-in-Place

a) Excavation and Bedding

Excavation shall be made to the required depth and the base upon which the kerb or combination of kerb and gutter is to be set shall be compacted to a minimum density of ninety (90) percent of the maximum dry density as determined by AASHTO T-191 Method. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer.

Where directed by the Engineer, a layer of cinders or clean sand and gravel, or other approved porous material having a minimum compacted thickness, of fifteen (15) cm shall be placed to form a bed for the kerb or combination of kerb and gutter.

b) Placing Concrete

Concrete may be placed in the gutter to the full depth required. The top of the kerb or combination of kerb and gutter shall be floated smooth and the edges rounded to the radii shown on the Drawings. Before finishing, the surface of the gutter shall be tested with a three (3) meter straight-edge and any irregularities of more than five (5) mm in three (3) meters shall be eliminated. In finishing concrete only mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

c) Joints

The kerb and gutter shall be constructed in uniform sections of not more than twenty five (25) meters in length except where shorter sections are required to coincide with the location of weakened planes or contraction joints of the concrete pavement or for closures but no section shall be less than two (2) meters long. The sections shall be separated by sheet templates set perpendicular to the face and top of the kerb and gutter. The templates shall be approximately five (5) mm in thickness, of the same width as that of the kerb or kerb and gutter and not less than five (5) cm greater than the depth of the kerb or kerb and gutter. Templates shall be set carefully and held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. When pre-cut fiber-board packing is used in the expansion joints it may be used in place of the sheet template referred to above, on the approval of the Engineer. In this event the fiber board shall be pre-cut to the shape of the kerb so that its outer edge will be flush with the abutting kerb.

Expansion joints shall be formed in the kerb and gutter at intervals of six (6) to ten (10) meters in order to coincide with the expansion joints of cement concrete pavement or as shown on the Drawing.

d) Dowels at Expansion Joints in Channels

At expansion joints in channels and in the channel portion of kerbs and channel built monolithically, painted dowel bars with slip sleeve shall be provided as a load transfer medium at locations shown on the Drawings.

The size and spacing of the dowel bars shall be as indicated on the Drawings. Each dowel shall be set accurately parallel to the top surface of the gutter and accurately at right angles to the expansion joint.

e) Contraction Joints

Transverse contraction joints shall be provided opposite to all contraction joints in abutting concrete pavement and other locations shown on the Drawing spaced to a maximum of four (4) meters.

The contraction joints shall be provided by forming grooves in the face and surface of structure at right angle to the kerb alignment and kerb surface. The grooves shall be rectangular in cross-section, five (5) cm deep by five (5) cm wide. The grooves shall be formed in the top of all kerbs and in the exposed roadway face of kerb and in the channel surface of monolithic type kerb and channels and in the surface of channels. The edges of the joints shall be tooled and the joints shall be left clean, neat and of specified width and depth.

f) Removal of Forms and Finishing

The forms shall be removed within twenty four (24) hours after concrete has placed except that the form used against the face of the kerb in a combination of kerb and gutter shall be removed as soon as the concrete has set sufficiently to hold its shape. Minor defects shall be repaired with mortar containing one part of portland cement and two parts of the fine aggregate. Plastering shall not be permitted on the face of a kerb or kerb and gutter and all rejected kerb or gutter shall be removed and replaced without additional compensation. All surfaces which will be exposed in the finished construction of the kerb and gutter shall be finished, while the concrete is still "green" by wetting a wood block of float and rubbing the surface until they are smooth.

g) Curing

During seventy two (72) hours following placing of concrete, the kerbs, channels and gutters shall be protected against premature drying by covering with suitable cotton or Hessian mats and by frequent sprinkling with water, with liquid forming compounds or with waterproof paper or by any other method as mentioned in section 401.3.8-Curing Concrete and approved by the Engineer.

h) Backfilling

After forms has been removed and concrete has been cured as specified, the excavation of kerbs, gutters or channels shall be backfilled with suitable earth or granular material tamped into place in layers of not more than fifteen (15) cms each until firm and solid.

601.3.2 Pre-Cast

a) Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with a suitable material acceptable to the Engineer.

Bedding shall consist of Class B Concrete conforming to the requirements of Item 401 and shall be to the section and dimension shown on the Drawings.

b) Placing

The precast concrete kerbs shall be set in 1:3 of cement sand mortar to the line, level and grade as shown on the Drawings or as directed by the Engineer.

c) Joints

Joints between consecutive kerbs shall be three (3) to five (5) mm wide and filled with cement mortar to the full section of the kerb.

d) Backfilling

Backfilling shall meet the requirements of Item 601.3.1(h).

601.3.3 Extruded Concrete Kerbing and Channels

a) Excavation and Bedding

Excavation and bedding shall conform to the requirements as described under item 601.3.1(a).

b) Placing

Concrete shall be fed to the machine at a uniform rate. The concrete shall be of such consistency that after extrusion it will maintain the shape of the kerb section without support and shall contain the maximum amount of water that will permit this result. The machine shall be operated under sufficient uniform restraint to forward motion to produce a well compacted mass of concrete which requires no further finishing other than light brushing with a brush filled with water only.

The forming tube portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine. A grade line gauge or pointer shall be attached to the machine so that a continual comparison can be made between the kerb being placed and the established kerb grade as indicated by an offset guide line.

The top end face of the finished kerb shall be true and straight and the top surface of the kerb shall be of uniform width, free from bumps or surface pits larger than fifteen (15) mm in diameter. When a straight-edge three (3) meters long is laid on the top or face of the kerb, or surface of the gutter, the surface shall not be more than five (5) mm from the edge of the straight-edge except at grade changes or curves.

Where adhesive is used to bond the kerb to an existing pavement, the surface shall be first thoroughly cleaned of all dust, loose material and oil, the cost of which shall be included in other items of work.

c) Joints

Expansion joints shall be constructed by sawing through the kerb section to its full depth. The width of the cut shall be such as to admit the joint filler with a tight fit. Preformed joint filler shall conform to the provisions of Item 601.2 and shall be inserted and mortared in place.
If sawing is performed before the concrete has hardened, the adjacent portion of the kerb shall be supported firmly with close fitting shields and the operations of sawing and inserting the joint filler shall be completed before curing the concrete.

Alternatively pre-cut joint fillers shall be permitted to be placed at the location of the expansion joints prior to the placing of the extruded kerb with the approval of the Engineer. The joint fillers shall be set firmly in place in a vertical position to the line and grade of the kerb profile.

d) Curing and Backfilling

Curing and backfilling shall be as described in item 601.3.1(g) and Item 601.3.1 (h).

601.4 MEASUREMENT AND PAYMENT

601.4.1 Measurement

The unit of measurement for concrete kerb, gutter, or combination of kerb and gutter, channel, or extruded kerbs and channels shall be measured by the linear meter along the front face of the section at the finished grade elevation. Deduction in length will be made for drainage structure installed in the kerbings such as catch basins and drop inlets etc. Measurement will not include any area in excess of those shown on the Drawings except for any area authorised by the Engineer in writing.

601.4.2 Payment

Measured and accepted quantities shall be paid for at the contract unit price per linear meter for each of the particular pay item listed below and shown in the Bill of Quantities which prices and payment shall constitute full compensation for furnishing and placing all materials for concrete, for reinforcing steel if required on the Drawings for expansion Joints, material, form for drainage opening, excavation, backfilling and dumping and disposal of surplus material and for all labour, equipment, tool and incidentals necessary to complete the item.

Payment for expansion joint filler material used in transverse expansion and contraction joints in kerbs and channel shall be understood to be included in the price tendered per linear meter for the kerbs and channels and shall not be paid for separately.

Concrete and mortar required for bedding of precast concrete kerbs as shown on the Drawings shall not be paid for as separated item, but the cost shall be included in the contract unit price for precast concrete kerb.

Pay Item No.	Description	Unit of Measurement
601 a	Providing and laying as shown on drawing Kerb stone 18”x12”x6” (450x300x150mm) laid in cement mortar as described in Specification including excavation and backfill(lean concrete should be paid under relevant item).	LM
601 b	RCC new Jersy barrier (In-situ) for median double face (Including Reinforcement)	LM
601 c	RCC new Jersy barrier (Pre-cast) for median double face (Including Reinforcement)	LM

SECTION 602 ASPHALT CONCRETE AND CEMENT CONCRETE SIDEWALK

602.1 DESCRIPTION

This work shall consist of the construction of sidewalks which can be asphalt concrete, plain portland cement concrete, or precast Portland cement concrete slabs (450x450) mm or smaller or interlocking concrete blocks all in accordance with these specifications and to the line, grade, levels and dimensions shown on the Drawings or as required by the Engineer.

602.2 MATERIAL REQUIREMENTS

602.2.1 Cement Concrete

The Concrete shall be either Class A or Class C as indicated on the drawings and in accordance with Item 401.1.1.

602.2.2 Asphalt Concrete

Asphaltic concrete shall conform to the requirements of Item 305 - Asphalt Concrete Pavement - for Class B mixture.

602.2.3 Expansion Joint Filler

Unless otherwise directed the joint filler shall have a thickness of five (5) mm and conform to the requirements of Item 601.2.

602.2.4 Forms

Forms shall be of wood or metal as approved by the Engineer and shall extend to the full depth of the concrete. All forms shall be straight, free from warp and of adequate strength to resist bending.

602.2.5 Bed Course Material

Bed course material shall consist of cinders, sand, slag, gravel, crushed stone or other approved materials of such gradation that all particles will pass through a 1/2" (12.5 m) sieve.

602.2.6 Asphaltic Prime Coat

Asphaltic prime coat material shall conform to the requirements of Item 301 for Cut-back Asphalt.

602.3 CONSTRUCTION REQUIREMENTS

602.3.1 Asphalt Concrete Sidewalk

(a) Excavation

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to minimum ninety (90) percent of the maximum dry density as determined by AASHTO T-191 Method. The surface shall be even conforming to the section shown on the drawings. All soft material shall be removed and replaced with acceptable material.

(b) Placing of Bed Course Material

The bed course material shall be compacted in layers not exceeding ten (10) cm, to the depth shown on the drawings and to the line and grade of the finished sidewalk surface.

(c) Priming the Bed Course Material

The prepared bed course material shall receive an application of prime coat in accordance with the requirements of Item 302 and approved by the Engineer.

(d) Placing the Asphalt Concrete

The asphalt concrete shall be placed on the previously primed prepared bed only when, in the opinion of the Engineer the bed is sufficiently dry and weather conditions are suitable. The mixture shall be placed on one or more courses of uniform thickness as shown on the Drawings. Each course shall be smoothed by raking or screeding and shall be thoroughly compacted by rolling with a hand operated roller or a type satisfactory to the Engineer. After compaction, the surfacing shall be of the thickness and section shown on the Drawings, shall be smooth, even and of a dense and uniform texture. Forms, if used, shall be removed and the shoulders shaped and compacted to the required section.

602.3.2 Cement Concrete Sidewalk

(a) Excavation

Excavation shall meet the requirements of Item 602.3.1 (a).

(b) Placing of Bed Course Material

Where indicated on the drawings the bed course material shall be placed in accordance with Item 602.3.1 (b).

(c) Forms and Expansion Joints

All forms shall be staked securely in position at the correct line and elevation.

Expansion joint filler shall be set in the position shown on the Drawings before the placing of the concrete is started. The joint filler shall be placed 5 mm below the top surface of the finished sidewalk.

(d) Placing the Cement Concrete Material

The mixing, placing, finishing, and curing of concrete shall be as provided under Item 401-Concrete.

Before the concrete has set, the surface of the concrete shall be trawled until it is of uniform smoothness and is true to the lines, elevations, and surface required.

The surface shall be cut through to a depth of one (1) cm with a trowel at intervals of one (1) meter or where required, in straight lines perpendicular to the edge of the sidewalk. The surface shall then be brushed. The edges of the sidewalk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges to a one and half (1.5) centimeters radius.

(e) Precast Elements

Precast concrete slabs or interlocking concrete blocks shall be set on the bed course material where indicated on the drawings or as directed by the engineer to provide a smooth top surface without ridges or lumps at joints.

Precast concrete units shall be fair faced cast to the sizes and dimensions as indicated on the drawings.

The concrete used for pre-cast unit shall conform to the specifications laid down in item 401-Concrete. The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer. All pre-cast units shall strictly conform to the approved sample.

A pre-cast unit cracked or damaged before, during or after erection shall be removed from the works and replaced by the Contractor at his own expense. All pre-cast units shall be smoothly finished to the required lines, grades angles etc. Holes, grooves, pockets, hooks shall be provided as shown or as directed by the Engineer.

The units shall be properly stacked on a platform without causing any cracks or damage. Curing of all the pre-cast units shall be done in accordance with item 401.

602.4 MEASUREMENT AND PAYMENT

602.4.1 Measurement

The quantity to be paid for shall be the number of square meters of asphalt concrete or cement concrete sidewalk complete in place and accepted, measured in the place of the sidewalk surface.

602.4.2 Payment

The quantity as determined above, shall be paid for at the contract unit price per square meter for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing and placing all materials, for asphaltic concrete, Portland cement concrete, expansion joint material, for excavating and compacting the foundation bed, for furnishing and placing for forms, and for all labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
602 a	Asphalt Concrete Sidewalk	SM
602 b	Cement Concrete Sidewalk	SM
602 c	Precast Concrete Slab Sidewalk	SM
602 d	Precast Concrete Interlocking Block Sidewalks	SM

SECTION 603 BRICK EDGING

603.1 DESCRIPTION

This item shall consist of brick installed on vertical edge between the pavement structure and shoulders in such a manner that the brick is laid on compacted shoulders and top of brick is flushed with the slope of road pavement.

603.2 MATERIAL REQUIREMENTS

603.2.1 Bricks

Quality of Bricks shall meet the material requirement as specified under item 410.

603.3 CONSTRUCTION REQUIREMENTS

A trench of appropriate dimensions shall be excavated to accommodate brick on vertical edge, so that top of the brick becomes flushed with the top of road pavement and to ensure that one face of the brick remains in contact with the pavement structure. The cavities on the other face of the brick shall be refilled with the excavated shoulder material and properly compacted. The brick shall be laid in accordance with the line and grade of the road pavement. It shall be ensured that bricks are installed in vertical positions.

603.4 MEASUREMENT AND PAYMENT

603.4.1 Measurement

Brick edging when laid and finished to the required grade and line shall be measured per linear meter installed and approved by the Engineer.

603.4.2 Payment

The quantity as measured above shall be paid per linear meter for excavation of trench, installation of bricks, compacted backfill of cavities and dressing of berms including material, watering, tamping, labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
603 a	Brick edging (3" WIDE, 9" Deep) complete in all respect.	LM

SECTION 604 METAL BEAM GUARD-RAIL

604.1 DESCRIPTION

This item shall consist of metal beam Guard rail constructed in accordance with these specifications at the locations and in conformity with the dimensions, and design shown on the Drawings or as ordered by the Engineer.

604.2 MATERIAL REQUIREMENTS

604.2.1 Metal Beam Guard Rail

The rail elements shall be galvanized corrugated steel beam conforming to the requirements of AASHTO M 180 of the designated type and class.

The mechanical properties of the base metals for beams shall conform to the following requirements:

Yield Point	-	3500 kg / sq. cm. (Minimum)
Tensile Strength	-	4900 kg / sq. cm. (Minimum)
Elongation	-	not less than 12 percent in a 2 inch (5.08 cm) gauge length when tested in accordance with ASTM E 8.

In addition to the above, the rail shall withstand a cold bend without cracking of one hundred eighty (180) degree around a mandrel of a diameter equal to two and half (2.1/2) times the thickness of the plate.

604.2.2 End or Buffer Sections

The end or buffer sections shall be formed from open hearth, electric furnace or basic oxygen steel. The section shall be of the same or superior class and type used for the beam to which it is attached.

604.2.3 Connections and Splices

All connections or splices shall be formed with oval shoulder button - headed bolts to minimize projections on the side of the guard. All bolts and nuts for beams shall conform to or exceed the requirements of ASTM A 307 and shall be galvanized as specified in ASTM A 153. The bolted connection of the rail element to the post shall withstand a two thousand two hundred seventy (2270) kg pull at right angles to the line of the railing.

604.2.4 Guard Rail Posts

Posts shall be of either steel or concrete as specified. Only one type of post shall be used for any one continuous Guard rail, except at junctions between bridges and approach embankments.

a) Steel posts shall be galvanized and of the section and length specified or as shown on the Drawings. They shall conform to the requirements of AASHTO M 183 for the grade specified.

b) Precast reinforced concrete posts shall be of a section and length as specified or as shown on the Drawings. The concrete shall be class C as specified in Item 401.1.1. Reinforcement shall conform to the requirements of AASHTO M 31 or M 53. All bars shall be of the deformed type, conforming to AASHTO M 31 or M 42.

604.2.5 Wooden Spacer Blocks

Wooden spacer blocks between the Guard rail and the posts shall conform to AASHTO M-133 and M-168 and be constructed to the section and length specified or as shown on the Drawings.

604.2.6 Post Foundation Blocks

Where required or as ordered by the Engineer, post foundation blocks shall be constructed in Class A concrete as specified in Item 401.1.1, to the section and length specified or as shown on the Drawings.

In order to facilitate the removal of posts damaged by vehicle impact, posts shall be set in galvanized tubular steel sockets cast into foundation blocks. The sockets shall be of internal dimension (s) after galvanizing such that there is a clearance of 3 to 5 mm between the socket and the guard rail post. Following erection of guardrails, the space between posts and sockets shall be filled with epoxy mortar.

604.3 CONSTRUCTION REQUIREMENTS

All posts shall be set vertically in the position shown on the Drawings and where embedded in a concrete foundation block shall remain undisturbed for a minimum of forty eight (48) hours. The space around the post or post foundation blocks shall be backfilled to the ground line, with selected earth containing no rocks, in layers of not exceeding ten (10) cm and each layer shall be moistened and thoroughly compacted. Where steel posts are driven into the ground no buckled post or deformed head shall be accepted.

604.3.1 Erection of Rail

All metal work shall be fabricated in the shop and no cutting or welding shall be done in the field unless otherwise ordered by the Engineer. Rail elements shall be lapped so that the exposed ends will not face approaching traffic. Terminal sections shall be installed in accordance with the manufacturer's recommendation.

604.4 MEASUREMENT AND PAYMENT

604.4.1 Measurement

The Guard rail shall be measured by the linear meter from center to center of end posts for each completed section fastened in place and accepted.

Guard rail end pieces shall be measured by the number completed in place and accepted.

Post for Guard rail shall be measured by the number erected in place and accepted.

604.4.2 Payment

The quantities determined as prescribed above shall be paid for at the contract price per unit of measurement for the pay item listed below and shown in the Bill of Quantities which price shall be full compensation for furnishing placing all materials, for foundations, for provision and erection of posts for excavation and backfill, for installation and fastening, and for all costs including labour, tools and incidentals necessary to complete the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
604 a	Metal Guardrail	LM
604 b	Metal Guardrail End Pieces	NO
604 c	Steel Post for Metal Guardrail	NO

SECTION 605 CONCRETE BEAM GUARD RAIL

605.1 DESCRIPTION

This item shall consist of concrete beam Guard rail constructed in accordance with these specifications at the locations and in conformity with the dimensions, and design shown on the Drawings.

605.2 MATERIAL REQUIREMENTS

605.2.1 Concrete Beam Guard Rail

The rail shall be of concrete Class A as specified in item 401.1.1 "Structures". Reinforcing steel shall conform to requirement as specified in item 404. Concrete beam Guard rail shall be of size 125 mm x 300 mm, where as reinforcing steel shall be provided at the rate of one hundred twenty (120) Kg. per cubic meter.

605.2.2 Connections and Splices

Bolts, nuts, washers, sleeves and other fittings shall conform to ASTM Designation A 325 (AASHTO M 614) and shall be zinc coated in accordance with the requirement of ASTM Designation A 153 (AASHTO M 232).

605.2.3 Guard Rail Posts

Post shall be of concrete Class A as specified in item 401.1.1 of these Specifications.

Precast reinforced concrete posts shall be of a section 250 mm x 250 mm. The concrete shall be Class A as specified in Item 401.1.1. Reinforcement shall conform to the requirements of AASHTO M 31 or M 53. All bars shall be of the deformed type, conforming to AASHTO M 137. Reinforcing Steel shall be provided at the rate of one hundred twenty (120) kg per cubic meter.

605.2.4 Post Foundation Blocks

Where required or as ordered by the Engineer, post foundation blocks, shall be constructed in concrete Class C as specified in Item 401.1.1 to the section and length specified or as directed by the Engineer.

605.3 CONSTRUCTION REQUIREMENTS

605.3.1 Formwork

Formwork shall be supplied and fixed in the position required for the concrete to be cast as shown on the Drawings, or as required by the Engineer, and shall be supplied, erected and removed as specified in Item 403.

605.3.2 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the Drawings, or where required by the Engineer, and its furnishing, bending and fixing shall be in accordance with Item 404.

605.3.3 Concrete

Concrete Class D1 as shown on the Drawings or as required by the Engineer shall be supplied, placed, finished and cured as specified in Item 401.

605.4 MEASUREMENT AND PAYMENT

605.4.1 Measurement

The Guard rail shall be measured by the length in meter of completed section fastened in place and accepted.

Guard rail end pieces shall be measured by the length in meter completed in place and accepted.

Posts for guard rail and guard rail end pieces shall be measured by the number erected in place and accepted.

605.4.2 Payment

The quantities, determined as prescribed above shall be paid for at the contract price per unit for measurement for the pay item listed below and shown in the Bill of Quantities which price shall be full compensation for fabrication of items in length as directed, including concrete, steel, formwork, transportation, erection and fastening of posts and Guard rail, making and filling of holes, and for all costs including labour, tools and incidentals necessary to complete the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
605 a	Concrete Beam Guardrail (Including Reinforcement)	CM
605 b	Concrete Post for Guardrail (Including Reinforcement)	CM

SECTION 606 BRIDGE RAILING

606.1 DESCRIPTION

This work, consists of the supply and erection of concrete railing for bridges and other structures in accordance with these specifications and to the details shown on the Drawings.

Where metal beam Guard rails form part of the Bridge Railing, the Guard rail beam and connections shall conform to the requirements of item 604 and shall be paid for under that item.

606.2 MATERIAL REQUIREMENTS

606.2.1 Formwork

Formwork where necessary, shall conform to Item 403.

606.2.2 Steel Reinforcement

Steel reinforcement shall be as specified in Item 404.

606.2.3 Concrete

Concrete shall be class D1 as specified in item 401.1.1 or as shown on the Drawings.

606.3 CONSTRUCTION REQUIREMENTS

606.3.1 Formwork

Formwork shall be supplied and fixed in the position required for the concrete to be cast as shown on the Drawings, or as directed by the Engineer, and shall be supplied, erected and removed as specified in Item 403.

606.3.2 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the drawings or where directed by the Engineer and its furnishing, bending, and fixing shall be in accordance with the Item 404.

606.3.3 Concrete

Concrete class D1 as shown on the drawings or as directed by the Engineer shall be supplied, placed, finished and cured, as specified in Item 401.

606.4 MEASUREMENT AND PAYMENT

606.4.1 Measurement

Concrete in place and accepted shall be measured as specified in Item 401.

The formwork in place and accepted shall not be measured separately as specified in Item 403.

Steel reinforcement in place and accepted shall be measured for as specified in Item 404.

606.4.2 Payment

Payment shall be made for the materials utilized, or the rates quoted by contractor and measured as provided above, for following items.

SECTION 607 TRAFFIC ROAD SIGNS AND SAFETY DEVICES

607.1 DESCRIPTION

This work shall comprise furnishing and installing traffic signs, permanent safety devices and post assemblies in accordance with these specifications and to the details shown on the Drawings. All sign faces and lettering shall be in accordance with NHA / NTRC sign standards or as shown on plans. Prior to manufacture and fabrication of the signs the contractor shall submit to the Engineer for approval detailed drawings showing letter sizes, traffic symbols and sign layout. The permanent safety devices shall consist of road posts and hazard markers and will be provided as per specifications, drawings or as directed by the Engineer.

607.2 MATERIAL REQUIREMENTS

607.2.1 Sign Panels

Sign panels for regulatory, warning and informatory signs shall be manufactured from Aluminium alloy conforming to ASTM B 209, alloy 6061-T6 or 5052-H38 plates of three (3) mm thickness as shown on the drawings.

The planks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the plank commercially flat. Perform shearing, cutting and punching before preparing the planks for application of reflective material.

The planks shall be cleaned, degreased, and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacturer.

607.2.2 Reflective Sheeting

Reflective sheeting used on road sign shall be made of flexible white or colored, wide angle retroreflective sheeting (herein after called sheeting), and related processing materials designed to enhance nighttime visibility. The sheeting shall consist of prismatic optical elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface. Sheeting shall comply with ASTM D-4956-09 and shall be of one of the following six (6) types as specified:

Type-III A high-intensity retroreflective sheeting, that is typically encapsulated glass-bead retroreflective material.

Type-IV A high-intensity retroreflective sheeting. This sheeting is typically an unmetallized microprismatic retroreflective element material.

Type-V A super-high-intensity retroreflective sheeting. This sheeting is typically a metallized microprismatic retroreflective element material suitable for **long** distances.

Type-VIII A super-high-intensity retroreflective sheeting having highest retro reflectivity characteristics for **medium** and **long** distances. This sheeting is typically an unmetallized cube corner microprismatic retroreflective element material.

Type-IX A super-high-intensity retroreflective sheeting having highest retro reflectivity characteristics for **short** distances. This sheeting is typically an unmetallized cube corner microprismatic retroreflective element material.

Type-XI A super-high-intensity retroreflective sheeting having highest retro reflectivity characteristics for **medium** and **short** distances. This sheeting is typically an unmetallized cube corner microprismatic retroreflective element material.

The sheeting shall have either a precoated pressure sensitive adhesive or a tack-free adhesive activated by heat applied in a heat vacuum applicator in a manner recommended by the sheeting manufacturer. Both adhesive classes shall be protected by an easily removable liner.

The manufacturer of the sheeting being offered shall furnish the process inks, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements of this specification and shall further be responsible for technical assistance in the use of these inks or alternatively sheeting can be used on sheeting.

The sheeting manufacturer shall provide test reports from internationally recognized laboratories showing compliance with the applicable standards for the type of sheeting to be used in the project. The manufacturer must also provide documented evidence to the satisfaction of the Engineer that representative production materials of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least three years.

a) Color Requirements. Daytime color shall be specified and conform to the requirements of Table 607-1A. Nighttime color shall be specified and conform to the requirements of Table 607-1B

TABLE 607-1A

COLOR SPECIFICATION LIMITS AND REFERENCE STANDARDS [1]
(DAYTIME)

Color	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390
Fl. Yellow*	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442

*Fl. Yellow = Fluorescent Yellow

TABLE 607-1B

COLOR SPECIFICATION LIMITS AND REFERENCE STANDARDS [1]
(NIGHTTIME)

Color	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	No Requirement							
Yellow	0.513	0.487	0.500	0.470	0.545	0.425	0.572	0.425
Orange	0.595	0.405	0.565	0.405	0.613	0.355	0.643	0.355
Green	0.007	0.570	0.200	0.500	0.322	0.590	0.193	0.782
Red	0.650	0.348	0.620	0.348	0.712	0.255	0.735	0.265
Blue	0.033	0.370	0.180	0.370	0.230	0.240	0.091	0.133
Brown	0.595	0.405	0.540	0.405	0.570	0.365	0.643	0.355
Fl. Yellow	0.554	0.445	0.526	0.437	0.569	0.394	0.610	0.390

[1] The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimeter System measured with CIE Standard Illuminant D65

b) Coefficient of Retroreflection. The coefficients of retroreflection shall conform to the minimum following requirements for each type of sheeting.

TABLE 607-2

MINIMUM COEFFICIENT OF RETROREFLECTION – TYPE-III SHEETING
(CANDELAS PER LUX PER SQUARE METER)

Observation Angle (º)	Entrance Angle (º)	White	Yellow	Orange	Green	Red	Blue	Brown
0.2	-4	250	170	100	45	45	20	12
0.2	+30	150	100	60	25	25	11	8.5
0.5	-4	95	62	30	15	15	7.5	5.0
0.5	+30	65	45	25	10	10	5.0	3.5

TABLE 607-3

MINIMUM COEFFICIENT OF RETROREFLECTION – TYPE-IV SHEETING
(CANDELAS PER LUX PER SQUARE METER)

Observation Angle (º)	Entrance Angle (º)	White	Yellow	Orange	Green	Red	Blue	Brown	Fl. Yellow
0.2	-4	360	270	145	50	65	30	18	220
0.2	+30	170	135	68	25	30	14	8.5	100
0.5	-4	150	110	60	21	27	13	7.5	90
0.5	+30	72	54	28	10	13	6	3.5	40

TABLE 607-4

MINIMUM COEFFICIENT OF RETROREFLECTION – TYPE-V SHEETING (CANDELAS PER LUX PER SQUARE METER)

Observation Angle (°)	Entrance Angle (°)	White	Yellow	Orange	Green	Red	Blue
0.2	-4	700	470	280	120	120	56
0.2	+30	400	270	160	72	72	32
0.5	-4	160	110	64	28	28	13
0.5	+30	75	51	30	13	13	6.0

TABLE 607-5

MINIMUM COEFFICIENT OF RETROREFLECTION – TYPE-VIII SHEETING (CANDELAS PER LUX PER SQUARE METER)

Observation Angle (°)	Entrance Angle (°)	White	Yellow	Orange	Green	Red	Blue	Brown	Fl. Yellow
0.2	-4	700	525	265	70	105	42	21	420
0.2	+30	325	245	120	33	49	20	10	200
0.5	-4	250	190	94	25	38	15	7.5	150
0.5	+30	115	86	43	12	17	7.0	3.5	69

TABLE 607-6

MINIMUM COEFFICIENT OF RETROREFLECTION – TYPE-IX SHEETING (CANDELAS PER LUX PER SQUARE METER)

Observation Angle (°)	Entrance Angle (°)	White	Yellow	Orange	Green	Red	Blue	Fl. Yellow
0.2	-4	380	285	145	38	76	17	230
0.2	+30	215	162	82	22	43	10	130
0.5	-4	240	180	90	24	48	11	145
0.5	+30	135	100	50	14	27	6.0	81
1.0	-4	80	60	30	8.0	16	3.6	48
1.0	+30	45	34	17	4.5	9.0	2.0	27

TABLE 607-7
MINIMUM COEFFICIENT OF RETROREFLECTION – TYPE-XI SHEETING (CANDELAS PER LUX PER SQUARE METER)

Observation Angle (°)	Entrance Angle (°)	White	Yellow	Orange	Green	Red	Blue	Brown	Fl. Yellow
0.2	-4	580	435	200	58	87	26	17	350
0.2	+30	220	165	77	22	33	10	7.0	130
0.5	-4	420	315	150	42	63	19	13	250
0.5	+30	150	110	53	15	23	7.0	5.0	90
1.0	-4	120	90	42	12	18	5.0	4.0	72
1.0	+30	45	34	16	5.0	7.0	2.0	1.0	27

For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 70% of the values for corresponding color in the above tables.

c) Daytime Luminance Factor. Daytime luminance factor shall conform to the following requirements for each type of sheeting.

TABLE 607-8

DAYTIME LUMINANCE FACTOR (Y %)

	All Except Type-V		Type-V	
Color	Minimum	Maximum	Minimum	Maximum
White	27	-	15	-
Yellow	15	45	12	30
Orange	10	30	7.0	25
Green	3.0	12	2.5	11
Red	2.5	15	2.5	11
Blue	1.0	10	1.0	10
Brown	1.0	9.0	1.0	9.0
Fl. Yellow	40			

The sheeting manufacturer shall provide a test report from any internationally recognised laboratory stating that the sheeting meets the requirements of ASTM D-4956 as stated in this specification for each type of sheeting.

The brightness of the reflective sheeting totally wet by rain shall be at least ninety (90) % of the above values.

d) Performance Requirements and Obligation. The sign manufacturer shall submit a certificate from the sheeting manufacturer stating that the sheeting used for finished retroreflective signs meets all requirements listed herein.

Sheetings processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendation, shall perform effectively after the number of months stated in Table 607-9 for each type of sheeting. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that:
(1) The sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or
(2) The sheeting shows appreciable cracking, scaling, pitting, blistering, edge lifting, or curling, or more than 0.8 mm shrinkage or expansion when tested in accordance with ASTM D-4956; or
(3) The coefficient of retroreflection is less than the minimum specified for that sheeting after accelerated weathering for the period listed in Table 607-9.

Table 607-9

OUTDOOR WEATHERING PHOTOMETRIC REQUIREMENTS [2]
FOR ALL CLIMATES

Sheeting	Months	Minimum Coefficient of Retroreflection R_A
Type-III	36	80% of Table 607-2
Type-IV	36	80% of Table 607-3
Type-V	36	80% of Table 607-4
Type-VIII	36	80% of Table 607-5
Type-IX	36	80% of Table 607-6
Type-XI	36	80% of Table 607-7

[2] Tested in accordance with ASTM D-4956 (6.4 Accelerated outdoor weathering requirements)

For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 50% of the values for the corresponding color in the above tables.

All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

Where it can be shown that retroreflective traffic signs supplied and used according to the sheeting manufacturer's recommendations have not met the above performance requirements, the sheeting manufacturer shall cover restoration costs as follows for sheetings shown to be unsatisfactory.

a) During the entire seven years the sign manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

b) In addition, during the first seven years sign manufacturer and sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to NHA for materials, labor, machinery and transportation etc.

Samples of the reflective sheeting shall be approved by the Engineer prior to the Contractor placing his order.

The sheeting shall also comply with the following when tested in accordance with ASTM D-4956 (Supplementary Requirements).

Flexibility:
The reflective sheeting shall be sufficiently flexible as to permit application over and adhesion to a moderately embossed surface. It shall not show any cracking when bent in one S around 3.2mm diameter mandrill at Zero (0) deg. C. Size of test specimen shall be 70mm x 279mm

Impact Resistance:

The sheeting, when applied to 76mm x 127mm x 1.016mm 6061-T6 aluminium test panel, shall show no cracking or delamination outside of the actual area of impact after being subjected to the dropping of a 1.82kg hammer with 15.8mm diameter rounded tip. Test shall be conducted after placing the sample at 23$\pm$2 deg C and 50$\pm$5 relative humidity for 24 hours.

Adhesion:

When tested in accordance with ASTM D-4956 (S2.2.3) sheeting shall produce a bond to support 0.79 kg weight for 5 minutes without the bond peeling off for a distance of more than 1.0 inch (25.4mm)

Outdoor Weathering:

The reflective material shall be weather-resistant and following cleaning, shall show no definite fading, darkening, cracking, blistering or peeling and shall have not less than Seventy Five (75) % of the specified wet or dry minimum brightness values when exposed to normal weathering for seven (7) years.

607.2.3 Metal Posts

Wide flange of 10 x 10 centimeters metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A-283 Grade-D.

In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty three (63) mm and seventy five (75) mm respectively conforming to the specifications of ASTM A-501.

All posts shall be thoroughly cleaned, free from grease, scale and rust, and shall be given one coat of rust inhibitive priming paint and two coats of grey paint. Length of the posts shall be such that their top flushes with the top of the sign penal, where as bottom of sign panel is at least hundred and eighty (180) centimeters above shoulder level.

607.2.4 Plates

a) Plates shall be non-porous, smooth, flat, rigid, weather proof and shall not rust or deteriorate otherwise.

It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of thirty seven and half (37.5) mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

b) The reflective sheeting for the background should cover the whole area of the sign plate.

c) Prior to application of the reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaner. The plate shall be rinsed thoroughly and dried with hot air before applying the sheets.

d) The sheeting after application to the sign base shall not come off the edges, which shall be sealed, nor shall it peel off nor warp. The surface shall be smooth and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weather-proof.

607.2.5 Nuts and Bolts

All Nuts and bolts and metal washers shall be of heavily galvanized quality ten (10) mm dia. (G. I.) or aluminium alloy. The bolt heads to be such that they do not protrude out too much nor show very much on the front face of the plate. The heads should be flush with the plate face and covered with sheeting galvanised according to ASTM A-153.

607.2.6 Rubber Washer

All rubber washers shall have thick walls and shall not get dry and brittle when exposed to weather at the site after they are in position during the life of the sign.

607.2.7 Caps over the pipes

These can be of heavy plastic or of aluminium well fitted so that they cannot be removed; any good adhesive can be used.

607.2.8 General

a) Very large signs need not be made of one piece; in that case extended Aluminium panels shall be used or the various pieces of sheet shall be joined by angle-irons in anticorodal materials, and, if necessary, with connecting cross pieces in order to ensure the solidity of the joint and with slanting struts embedded in the concrete as directed by the Engineer.

b) All the nuts and bolts and metal washers must be heavily galvanized, or may be of stainless steel of high quality.

c) Relevant holes to receive ten (10) mm bolts shall be drilled into the pipes and the plates and not punched. These to be drilled through the plates before the application of scotchlite.

d) After the plates are fixed with nuts and bolts, the nuts shall be TACK WELDED to the bolts against pilferage.

607.2.9 Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ Class A in accordance with Item 401.1.1 and shall of the size 450 x 450 x 650 mm for category 1 & 2 and 600 x 600 x 750 mm for category 3.

607.2.10 Road Posts, Delineators and Hazard Markers

The road posts, delineators and hazard markers used as permanent safety devices shall conform fully with the requirements of the statutory instruments, latest British Standards and chapter four (4) of the Traffic signs manual. The safety devices shall consist of delineators and detours of verge master, flex master, edge master, passing place post, and chevroflex etc. and will be manufactured from highly durable tough plastic material with standing vehicular impact. These shall be of Type-V or Type-VIII reflective sheeting as specified for maximum visibility by both day and night and consequently shall be resistant to impact, damage and vandalism.

607.2.11 Road Side Mirror

Size: 45cm circular or 80cm circular.

Post: 7ft high G.I pipe 3 inch dia.

Mirror: stainless steel back with bracket to fix on a G.I pipe 3 inch dia at an angle to suit the location. Front reflective surface must be scratch proof. Totally assembly must be unbreakable due to wind load of 70mph.

Specification

Application	Outdoors	Outdoors
Lens material	Polycarbonate	Polycarbonate
Mounting kit fixing to	1.5”/48mm diameter post	2.5”/76mm diameter post
Lens diameter	1.4’/45cm	2.6’/80cm
Weight	4.4 lbs/2.0 kg.	13.9 lbs/6.3 kg.

607.3 CONSTRUCTION REQUIREMENTS

607.3.1 Excavation and Backfilling

Holes shall be excavated to the required depth of the bottom of the concrete foundation as shown on the Drawing.

Backfilling shall be carried out by using the surplus excavated material if approved by the Engineer and shall be compacted in layers not exceeding fifteen (15) cm in depth.

Surplus excavated material shall be disposed of by the Contractor as directed by the Engineer.

607.3.2 Erection of Posts

The posts shall be erected vertically in position inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the setting process of the concrete. The posts shall be located at the positions shown on the Drawings.

607.3.3 Sign Panel Installation

Sign panels shall be installed by the Contractor in accordance with the details shown on the Drawings. Any chipping or bending of the sign panels shall be considered as sufficient cause to require replacement of the panels at the Contractor's expense.

The exposed portion of the fastening hardware on the face of the sign shall be painted with enamels matching the background colour.

All newly erected traffic road signs shall be covered with burlap or other material until their uncovering is ordered by the Engineer.

607.3.4 Categories of Signs

Traffic road signs shall be of three categories according to type of construction

a) Warning Signs

Constructed with single post and sign of equilateral triangle shape, as shown in drawings, category 1.

b) Regulatory Signs

Constructed with single post and sign of circular shape, as shown in the drawings, category 2.

c) Informatory Signs

These signs shall be rectangular in shape and constructed with one, two or three numbers of posts or as shown on the drawings. Dimensions may vary according to the requirements, however total area of sign shall be as under:-

Category 3 a = One Sq. meter
Category 3 b = Two Sq. meter
Category 3 c = As shown on drawings

d) Additional panel

If any panel is required to be installed, it shall be of the sizes 60x30 cm or 90x30 cm.

For details of panels, Standards Drawings may be referred to.

607.3.5 Installation of Safety Devices

Safety devices comprising of road posts, delineators of various types, fixed / portable safety barriers and hazard markers e.g. verge-master, flex-master chevroflex, bigmax, edge master and passing place post and other etc., shall be installed in accordance with the techniques and methods laid down in the manufacturer's manual or guide and in conformity to the line and level and locations shown on the drawings or as directed by the Engineer to ensure maximum visibility and safety, even in adverse weather conditions. These shall be constructed strictly with the specifications and full assistance by the manufacturer for installation with precision. These safety devices shall be used as delineators at sharp curves of highways verges, high embankments, culverts, bridges, as a visual and physical deterrent for a prohibiting car parking on grass verges and protecting kerb-side areas on public and private roads.

607.3.6 Sign faces

a) Design

All sign faces shall be of the type, colour, design and size as shown in the plans. Size and spacing of letters shall be as under:

1.	The Urdu writing shall be in "Persian" character.	
2.	The Urdu and English writing shall be about the same in length, width and spacing.	
3.	English letters are to be in italics except the first letter of the word, which is to be in capital.	
4.	Height of Capital letters	21 cm
5.	Height of italics letters	17 cm
6.	Stroke Width and Width of border	3.5 cm
7.	Space between words and border (at least)	5 cm
8.	Space between Words	5 cm
9.	Space one line will occupy	4 cm
10.	Space between digits of numerals	4 cm
11.	Height of numerals same as capital letters	23 cm
12.	Space between lines (at least)	5 cm

13. Size of letter for “km”. Height K - 23 cm

m - 8 cm

14. Width of letters for “km” including spacing K - 8 cm

m - 9.6 cm

15. Width of dividing line 2.0 cm

16. The size and spacing for Urdu letter and Words will generally conform to the dimensions shown above for English letters.

17. The spelling of place names in Urdu and in English shall be as written in the Survey of Pakistan, maps.

b) Shop Drawings

The contractor shall submit to the Engineer for approval, three (3) copies of drawings for all special sign faces and all sign faces bearing messages, showing the design and/or arrangement and spacing of both the Urdu and English sign messages. Official town names and their spelling shall be as provided by the Engineer. Size and style of lettering shall be as shown on the plans or as otherwise approved by the Engineer.

607.3.7 Storage of Signs

Signs delivered for use on a project shall be stored off ground and under cover in a manner approved by the Engineer. Any signs damaged, discolored or defaced during transportation, storage or erection shall be rejected.

607.4 TRAFIC LIGHT SIGNALS

Traffic light signals shall be Red, Yellow and Green lights, hoist in UV-Stabilized Polycarbonate material with IP rating IP65. These will be operated by power 100-240V AC or may be operated by battery with 12-24V DC. The viewing distance must be minimum 500m. The housing shall be of colour black or yellow as approved by the Engineer. The diameter of lens will be 200m (8”). The traffic signal will have proper brackets at the back with the facility to install horizontally and vertically on G.I pipe 3” dia.
Other parameters of specification will be as under

Table 607-10: Specification

Colour	Red	Amber	Green
Size	200mm (8”)	200mm (8”)	200mm (8”)
LEDs (Pcs x Wave length)	3 x 625nM	3 x 625nM	3 x 505nM
Luminance (cd)	>200	>200	>200
Module shape	Round	Round	Round
Power consumption (W)	<6W	<6W	<6W
Housing material	UV-Stabilized polycarbonate		
Sun visor material	Sheet aluminum, Horizontal or vertical attachment with 4 screws		

Cover shape	200 mm spherical radius, tinted optical polycarbonate lens
Voltage (V)	100-240V AC or 12-24V DC
Operating temperature (C)	-40 to +70
Viewing distance, angle	>500m, L/R 30, U/D 30
IP rating	IP65

The designer will decide about the installation on vertical or horizontal pole and use the concrete and G.I pipe available in the specification of Buildings.

In order to harmonize various signals on a cross road, the designer will use a control panel and PVC pipe underground to connect various signals.

607.5 MEASUREMENT AND PAYMENT

607.5.1 Measurement

The quantities of traffic road signs and safety devices to be paid for shall be measured in number of each category of sign supplied and installed at site as directed by the Engineer.

607.5.2 Payment

The quantities measured as determined above shall be paid for at the contract unit price for the pay items listed below, and as shown in the Bill of Quantities which price and payment shall be full compensation for furnishing all labour, materials, tools, equipment, and for excavation, concreting, backfilling and erection of posts, installation of sign panels and all incidental costs including sheeting/painting necessary to complete the work as prescribed in this item.

Pay Item No.	Description	Unit of Measurement
607 a	Traffic Road Signs Category 1 (Equilateral triangle 90x90x90cm)	NO
607 b	Traffic Road Signs Category 2 (Circular 105cm dia.)	NO
607 c	Traffic Road Signs Category 3-a (1SM area)	NO
607 d	Traffic Road Signs Category 3-b (2SM area)	NO
607 e	Traffic Road Signs Category 3-c (As per drawing)	SM
607 f	Additional panel size 60 x 30 cm	NO
607 g	Additional panel size 90 x 30 cm	NO
607 h	Road side mirror 36” dia. at curves and blind corner shall be installed on 3” dia G.I pipe (7’ height) including foundation concrete (Paid in concrete) as per drawing or as directed by the engineer.	NO
607 i	Traffic Signal with brackets	NO
607 j	Fixing of synthetic rubber speed breaker as selected/approved by Engineer In-charge according to manufacturer/vendors Specifications.	NO

SECTION 608 PAVEMENT MARKING

608.1 DESCRIPTION

This work shall consist of furnishing non reflective or reflective chlorinated rubber based or thermoplastic paint material or retroreflective preformed pavement marking (tape) whichever is called for in the Special Provisions and shown in the Bill of Quantities, for sampling and packing, for the preparation of the surface and for the application of the paint to the pavement surface all in accordance with these Specifications.

The paint shall be applied in conformance to the size, shape and location of the markings as shown in the Drawings.

608.2 CHLORINATED RUBBER PAINT

608.2.1 Material Requirements

A standard and acceptable quality of Chlorinated Rubber based paint conforming to AASHTO M-248 (Type-N) shall be used. The paint shall be ready for application and shall be of a smooth quality. The paint shall be homogeneous, well dispersed to a smooth consistency and shall not cake, liver, thicken, curdle, gel, settle badly or show any objectionable properties after period of storage not to exceed six (6) months.

Composition

a) **Alkyd Resin**

Alkyd Resin Type-N shall be supplied as 60 mass percent solution in toluene conforming to requirements of following table. The resin solids shall be a medium soya-modified pentaetythritol resin. The oil fatty acids shall be either alkali refined soya oil or fatty acids of soya oil having iodine number of 115 to 130. No. rosin, recovered oil, marine or soya food fatty acid derivatives shall be used.

Table 608-1: Required Properties for the Alkyd Resin Type-N

Characteristics	Alkyd Resin Type-N
Solids, mass percent	60 $\pm$ 1
Phthalic Acid, mass percent	30 min.
Oil Acids, mass percent	54 min.
Iodine No.	115 - 130
Color, gardner	9 max.
Acid Mumber	8 max.
Viscosity (reduced to 45 mass percent solids)	D to H

b) **Chlorinated Rubber**
Chlorinated rubber shall have a fixed chlorine content of 65.0 percent minimum when previously dried at 100 $\pm$ 5 deg. C for 24 hours

c) **White Traffic Paint**

i) Pigment used in formulation of paint shall meet following requirements:

Table 608-2

Requirements for the Pigment used in Formulation of White Paint

Pigment Ingredients	Mass Percent	
	Type N	
	Min	Max
Titanium Dioxide	29	31
Calcium Carbonate	34	36
Magnesium Silicate	34	36

ii) Vehicle Ingredient composition shall be as follows:

Table 608-3: Vehicle Ingredient Composition

Vehicle Ingredients	Mass Percent	
	Type N	
	Min	Max
Alkyd Resin Solids	79	81
Chlorinated Rubber	19	21

Stabilizer = Two (2) percent based on mass of chlorinated rubber

iii) Paint Composition shall meet the following requirements:

Table 608-4: Requirements for the Paint Composition

Characteristics	Requirements	
	Type N	
	Min	Max
Pigment, percent	57.0	59.0
Total Solids, percent	75.0	
Nonvolatile Vehicle, mass percent	41.0	
Density (kg / cubic meter)	1582	
Viscosity, Krebs units	70	80
Fineness, Hegman	3	
Drying Time, minutes		15

d) **Yellow Traffic Paint**

i) Yellow color shall match US Federal Test Standard Number 595B – Color 33538. Pigment used in formulation of paint shall meet following requirements:

Table 608-5

Requirements for the Pigment used in Formulation of Yellow Paint

Pigment Ingredients	Mass Percent	
	Type N	
	Min	Max
Lead Chromate	34	36
Calcium Carbonate	53	55
Magnesium Silicate	11	13

ii) Vehicle Ingredient composition shall be as follows:

Table 608-6: Vehicle Ingredient Composition

Vehicle Ingredients	Mass Percent	
	Type N	
	Min	Max
Alkyd Resin Solids	79	81
Chlorinated Rubber	19	21

Stabilizer = Two (2) percent based on mass of chlorinated rubber

iv) Paint Composition shall meet the following requirements:

Table 608-7: Requirements for the Paint Composition

Characteristics	Requirements	
	Type N	
	Min	Max
Pigment, percent	60.0	62.0
Total Solids, percent	76.5	
Nonvolatile Vehicle, mass percent	42.0	
Density (kg / cubic meter)	1678	
Viscosity, Krebs units	70	80
Fineness, Hegman	3	
Drying Time, minutes		15

e) **Black Traffic Paint**

Black Traffic Paint shall comply with US Federal Specifications TT-P-110C as follows:

Table 608-8: Requirements for the Black Paint

Characteristics	Requirements	
	Min	Max.
Pigment, percent by weight of paint	40	50
Nonvolatile vehicle, percent by weight of vehicle	31	-
Consistency, Krebs-Stormer, Shearing Rate 200 RPM:		
Type I	70	82
Type II	77	95
Drying time (no pick-up time), minutes:		
Type I	-	30
Type II	-	4
85 deg. Specular gloss	-	10
Uncombined water, percent by weight of paint	-	0.5
Coarse particles and skins, percent by weight of pigment	-	0.5

The volatile solvent shall not contain more than 0.4 percent of benzene.
The volatile solvent shall conform by volume to the requirements controlling the emission of solvents into the atmosphere as called out in (i), (ii, (iii), (iv), and (v).

Table 608-9: Requirements for the Volatile Solvent

(i)	A combination of aldehydes or branched chain ketones	20 percent maximum.
(ii)	A combination of aromatic compounds with eight or more carbon atoms to the molecule except ethylbenzene	8 percent maximum.
(iii)	A combination of ethylbenzene or toluene	20 percent maximum.
(iv)	A combination of solvents with olefinic or cyclo-olefinic unsaturation	5 percent maximum.
(v)	Total of (i) + (ii) + (iii) + (iv)	20 percent maximum.

The volatile material shall be of such character that has a minimum solvent action of asphalt, and such that the resins and non-volatile components will be entirely dissolved in the volatile material, and will not precipitate from the solution on standing. The non-volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to the sunlight.

Other pavement marking paint may be submitted by the Contractor as an alternative to the above, for the approval of the Engineer.

608.2.1.1 Glass Beads for Reflective Road Paint

Glass beads shall conform to AASHTO Designation M-247. At least ninety (90) percent beads shall be transparent, clean, colorless glass, smooth and spherically shaped, free from milkiness, pits, or excessive air bubbles. The grading of glass beads dispersed in the paint shall be one of the following:

Table 608-10

Requirements for the Glass Beads for Reflective Road Paint

Sieve Designation	Mass Percentage Passing	
	Type-1	Type-2
No. 20 (0.850 mm)	100	100
No. 30 (0.600 mm)	75 – 95	100
No. 40 (0.425 mm)	-	90 – 100
No. 50 (0.300 mm)	15 – 35	50 – 75
No. 80 (0.180 mm)	-	0 – 5
No. 100 (0.150 mm)	0 – 5	-

The proportion of glass beads to paint shall be not less than five hundred (500) grams per litre of paint.

608.2.2 Photometric Requirements for Reflective Road Paint

Other reflective road paints may be considered for use by the Engineer provided they have minimum brightness values at two tenth (0.2) degree and half (0.5) degree divergence expressed as candle power per lux per square meter of surface coating, as follows:

Table 608-11: Photometric Requirements for Reflective Road Paint

Entrance Angle	Color			
	White		Yellow	
	Observation Angle (Degree)			
	0.2	0.5	0.2	0.5
	Brightness Values (cd / lx / m^2)			
(-) 4 Degree	237	118	129	75
40 Degree	75	43	43	32

608.2.3 CONSTRUCTION REQUIREMENTS

Traffic markings shall be applied with approved equipment capable of applying the paint at the specified width and at the specified rate of application. In no case shall the contractor proceed with the work until the equipment, method of application and rate of application as established by a test section have been approved by the Engineer

The painting of lane markers and traffic strips shall include the cleaning of the pavement surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic on the pavements, the protection of all parts of the road, structures or appurtenances against disfigurement by spatters, splashes or smirches of paint or of paint materials, and the supplying of all tools, labour and traffic paint necessary for the entire work.

The paint shall not be applied during rain, wet weather, when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unfavourable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavements which have absorbed heat sufficient to cause the paint to blister and produce a porous paint film.

The application of paint shall preferably be carried out by a purpose-made machine but where brushes are used only round or oval brushes not exceeding 10 cm. in width will be permitted. The paint, when applied, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted.

Traffic paint shall be applied to the pavement at a rate of one (1) litre to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

608.3 HOT-APPLIED THERMOPLASTIC ROAD PAINTS

Thermoplastic paint shall be reflectorized pavement stripping material that is applied to the road surface in a molten state by mechanical means with surface application of glass beads. Upon cooling to normal pavement temperature, it produces an adherent reflectorized stripe of specified thickness and width capable of resisting deformation by traffic. Thermoplastic Paint shall comply with the requirements of AASHTO M-249. Contrast marking – in bordered or line lead-lag layout - with compatible black material shall be applied, where specified, to enhance day-time visibility of road paint on light colored pavements.

608.3.1 Material Requirements

608.3.1.1 General

The thermoplastic material shall be homogeneously composed of pigment, filler, resins and reflectorized glass beads.

608.3.1.2 Composition

The vendor shall have the option of formulating the material according to his own specifications. However, the physical and chemical properties contained in this specification shall apply regardless of the type of formulation used. The material, upon heating to application temperature, shall not exude fumes which are toxic, or injurious to persons or property. The pigment beads and filler shall be well dispersed in the resin. The material shall be free from all skins, dirt, and foreign objects.

a) White Pigment.

The pigment shall be Titanium Dioxide complying with the requirements of ASTM D-476 Type-III Rutile.

b) Yellow Pigment.

Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided other requirements of this specification are met. Yellow pigment may be lead-free or may contain encapsulated Lead Chromate. Yellow color shall match US Federal Test Standard Number 595b – Color 13538

c) Other Materials.

The extender shall normally be calcium carbonate prepared from natural chalk complying with the requirements of ASTM D-1199 Type GC-II.

Glass Beads shall be uncoated and shall conform to the requirements of Item 608.2.1.1 (Type-1)

d) Binder.

The binder shall consist of synthetic hydrocarbon resin, or, with the approval of the Engineer, shall be alkyd resin.

e) Composition of mixture.

The pigment, beads, and filler shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt, and foreign objects and shall comply with the following requirements:

Table 608-12: Proportions of Constituents of Mixture

Component	White	Yellow
Binder	18.0 min	18.0 min.
Glass beads	30-40	30-40
Titanium Dioxide	10.0 min.	-
Calcium Carbonate and inert fillers	42.0 max.	See Item 608.3.1.2 (b)
Yellow pigments	-	

Pigment, where specified, shall be minimum 10% in the case of material to which surface glass beads are to be applied by pressure application.

The grading of the combined aggregate, Pigment, Extender and glass beads (where specified) as found on analysis shall comply with the following requirements:

TABLE 608-13

GRADING OF COMBINED AGGREGATE, PIGMENT, EXTENDER AND GLASS BEADS

BS Sieve	Percentage by mass, passing (Sprayed)
2.80 mm	100
600 micron	75-95

608.3.2 Sampling and Testing

608.3.2.1 Sampling

For the purpose of carrying out the testing, it is essential that adequate and representative samples be taken in the manner prescribed in specification AASHTO T-250 at following stages.

a) At the manufacturer's plant.
b) After it has been re-melted by the road application contractor.

608.3.2.2 Testing

The samples shall be prepared and tested in accordance with AASHTO Specification T-250. The test results shall conform to the following requirements.

Table 608-14: Physical Characteristics

No.	Test Description	Requirements
1	Softening point after heating for 4hrs at 218 ± 2 deg C (testing as per ASTM D-36)	102.5+9.5℃
2	Specific Gravity	2.15 max
3	Day light reflectance after 4hrs heating at 218 ± 2 deg C & cooled to 25 ± 2 deg. C	75% min – white 45% min – yellow
5	Drying time at air tem 10 ± 2 deg. C Air temp 32 ± 2 deg. C	2 min. (max) 10 min. (max)
6	Bond strength	180 psi (min)
7	Cracking resistance (low temp)	No crack
8	Impact resistance	1.13 J (min)
9	Flowability – Residue White Yellow	18 % Max 21 % Max
10	Flowability after extended heating	28% Max
11	Yellowness Index for white thermoplastic	0.12 Max
12	Skid Resistance (as per BS 3262 App. G)	45 Min

The chromaticity and luminance factors shall be within the limits in the following table when determined under following standard conditions:

(a) Angle of illumination, 45 degrees;
(b) Direction of view, perpendicular to surface; and
(c) Illuminant: CIE standard illuminant D65.

TABLE 608-15

CIE EQUATIONS FOR CHROMATICITY AND LUMINANCE

Yellow	
Orange boundary	y = 0.130 + 0.636x
White boundary	y = 0.910 – x
Green boundary	y = 1.35x – 0.093
Luminance factor	B= 0.27 (mnm)
White	
Purple boundary	y = x
Blue boundary	y = 0.610 - x
Green boundary	y = 0.040 + x
Yellow boundary	y = 0.710 - x
Luminance factor	B = 0.35 (mnm)

608.3.3 Manufacturing, Packing and Storing of Paint

608.3.3.1 Manufacturing

The paint shall be produced in a plant owned and operated by the manufacturer following a process which has been used by the manufacturer for at least five (5) years to produce paint. The equipment for mixing and grinding shall be clean, modern, and in good condition.

608.3.3.2 Packing

- The material shall be supplied in sealed containers which do not contaminate the contents and which protect them from contamination.
- Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, reflectorisation (if applicable), colour, chemical type of binder and maximum safe heating temperature.

608.3.3.3 Storing

The material shall be stored in accordance with the manufacturer's instructions and any material that is in damaged containers of which the seal has been broken, shall not be used. The material shall meet the requirements of this specification for a storage period of 1 year. The thermoplastic must also melt uniformly with no evidence of skins or un-melted particles for this 1-year time period. Any material not meeting the above requirements shall be replaced by the manufacturer.

608.3.4 Certification

The Contractor shall furnish a certificate from manufacturer that the material he proposes to use has the required properties, stating the maximum and minimum proportions and grading of the constituents, the acid value of the binder, the setting time, the maximum safe heating temperature, the temperature range of the apparatus and the proposed method of laying.

608.3.5 Application of Material to the Road.

a) Preparation of site.

The thermoplastic material shall be capable of being applied by spraying, screed extrusion or ribbon extrusion, as specified by the Engineer, at temperatures of 211 $\pm$ 7 deg. C from approved equipment to produce a line 3.2 to 4.8 mm thick which shall be continuous and uniform in shape having clear and sharp dimensions.

The material shall not exude fumes which are toxic, obnoxious or injurious to persons or property when it is heated during application.

The thermoplastic paint shall only be applied to surfaces, which are clean and dry. Immediately before the application of paint, the surface shall be cleaned with mechanical broom, compressed air or other approved means to remove surplus asphalt, oils, mud, dust and other loose or adhered material. The material shall not be applied if the road surface is at a temperature of less than 5^{o} C.

b) Preparation of material on site.

- The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material and such that local overheating will be avoided. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by

the manufacturer. The molten material shall be used as expeditiously as possible, and for thermoplastic material, which has natural resin binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

- After transfer to the laying apparatus, the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

- On concrete carriageway, a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions prior to the application of thermoplastic material.

c) Laying.

Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by self propelled machine. Other markings may be laid by hand, hand propelled machine or self propelled machine as approved by the Engineer. The surface produced shall be uniform in texture and thickness and appreciably free from blisters and streaks.

d) Reflectorization by surface application.

When surface application of glass beads is required, additional glass beads (400 g/m^2 to 500 g/m^2 from the machine) shall be applied by pressure concurrently with the laying of the line with sufficient velocity to ensure retention in the surface of the line. The glass beads so sprayed shall give uniform cover and immediate reflectivity over the whole surface of the marking.

e) Thickness

Unless otherwise approved by the Engineer, the material shall be laid to the following thicknesses.

a) Sprayed lines other than yellow. Not less than 1.5 mm.
b) Sprayed yellow edge lines not less than 0.8 mm.

The minimum thicknesses specified are exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with appendix H of BS 3262.

608.3.6 Trial Section

In no case shall the contractor proceed with the work until the equipment, method of application and rate of application conforming the required thickness (as established by a test section) have been approved by the Engineer.

608.4 RETRO REFLECTIVE PREFORMED PAVEMENT MARKINGS

The retroreflective pavement marking tape shall comply with the requirements of ASTM D-4505. The tape shall be white or yellow preformed retroreflective pavement marking tape, that when applied to a road surface, shall provide extended service life.

608.4.1 Materials - Requirements

The preformed markings shall consist of white or yellow films with pigments selected to conform to standard highway colours. Ceramic and glass beads shall be incorporated to provide immediate and continuing retroreflection. Ceramic skid particles shall be bonded to a top urethane layer to provide a skid resistant surface.

The preformed markings shall be capable of being adhered to asphalt cement concrete (ACC) or Portland Cement Concrete (PCC) by a precoated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. The preformed marking film shall mold itself to pavement contours by the action of traffic. The pavement marking film wearing courses during the paving operation in accordance with the manufacturer's instructions, approved by the Engineer. Following proper application and tamping, the markings shall be immediately ready for traffic. The bidder, when bidding, shall identify proper solvents and/or primers (where necessary) for proper application, and recommendation for application that will assure effective product performance. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

The marking film shall be durable retroreflective plisot polymer pavement marking film for performed longitudinal markings subject to low to medium traffic volumes and moderate wear conditions such as repeated shear action from crossover or encroachment on channelization lines.

The retroreflective pavement marking film shall consist of mixture of high-quality pigmented polymeric materials, with a reflective layer of ceramic and glass beads, and a layer of skid resistant ceramic particles bonded to the top urethane wear surface. The film shall have a pre-coated pressure sensitive adhesive. The edges of the preformed tape shall be clear cut and true.

608.4.2 **Colour:**

The daytime colour of the white film shall provide a minimum initial Luminance factor, Y, of 80, and shall conform to the following chromaticity requirements: X=0.290, Y=0.315; X=0.491, Y=0.435; X=0.512, Y=0.486; X=0536, Y= 0.463.

Measurements shall be made in accordance with ASTM E 1349, using illuminant "C" and 0/45 (45/0) geometry. Calculations shall be in accordance with ASTM E 308 for the 2^{o} standard observer.

608.4.3 **Retro-Reflectance.**

The white and yellow films shall have the following initial minimum reflectance values as measured in accordance with the testing procedures of ASTM D 4061. The photometric quantity to be measured shall be retro-reflective Luminance (R_L), and shall be expressed as millicandals per square meter per lux (mcd m^{-2} lx^{-1})

TABLE 608-16

RETRO-REFLECTANCE VALUES FOR NEW DRY SAMPLES

Entrance Angle (Deg)	Obs. Angle (Deg)	Reflectivity Level	R_L	
			White	Yellow
88.76	1.05	Reflectivity I	500	300
		Reflectivity II	250	175

608.4.4 **Skid Resistance**

The surface of the retro-reflective films shall provide an initial minimum skid resistance values of 55 BPN as measured by the British Portable Skid Tester in accordance with ASTM E-303.

608.4.5 **Patchability**

The pavement marking film shall be capable of use for patching worn areas of the same type of film in accordance with the manufacturer's instructions.

608.4.6 Reflectance Retention.

To have a good, effective performance life, the ceramic and glass beads must be strongly bonded and not be easily removed by traffic wear. The following test shall be employed to measure reflectivity retention.

608.4.6.1 Taber Abraser Simulation Test

Using a Taber Abraser with an H-18 wheel and a 125 gram load, the sample shall be inspected at 200 cycles, under a microscope, to observe the extent and type of bead failure. No more than 15% of the beads shall be lost due to popout and the predominant mode of failure shall be “wear down” on the beads.

608.4.7 Beads

The size, quality and refractive index of the ceramic and glass beads shall be such that the performance requirements for the marking shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched.

608.4.8 Bead Retention

The film shall be ceramic and glass bead retention qualities such that when a 2 in x 6 in. (5.08 cm x 15.24 cm) sample is bent over a 1/2 in. (1.27 cm) diameter-mandrel, with the 2 in. dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

608.4.9 Thickness

The film without adhesive shall have a minimum thickness of 0.030 in (0.76mm).

608.4.10 Effective Performance Life.

The film, when applied according to the recommendations of the manufacturer, shall provide neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and through normal traffic wear shall show no fading, lifting or shrinkage which will significantly impair the intended usage of the marking throughout its service life and shall show no significant tearing, roll back or other signs of poor adhesion. The service life of the pavement marking tape shall be greater than one (1) year, for up to Fifteen Thousand (15,000) average daily traffic count (ADT) per lane.

608.4.11 Installation

The markings shall be applied in accordance with the manufacturer’s instructions. Epoxy Resin adhesive for bonding pavement marking tape shall comply with AASHTO M-237.

608.5 CEMENTITIOUS MARKING COMPOUND

Cementitious marking compound shall be used for Concrete, Surface Dressing and Asphalt surfaces to provide enhanced night and wet weather visibility. This compound will be applied at following locations:

- Kerbs - Pavements and car park areas.
- Roundabouts - vertical and sloping faces.
- Traffic Islands - vertical edges and bull noses, etc.
- Traffic Dividers - black and white chevrons.
- Concrete walls and faces - on high speed intersections and traffic merging.

608.5 MEASUREMENT AND PAYMENT

608.5.1 Measurement

The quantity of non-reflective or reflective chlorinated rubber based or thermoplastic pavement marking paint, shall be the no. of linear meters of painted traffic line for the specified width as indicated in BOQ. The retroreflective preformed pavement markings (tape) shall be measured in square meters. The arrows shall be measured in number.

The measurement shall be made of painted areas, completed and accepted. No measurement shall be made of unauthorized areas. Paint that is applied in un-authorized areas shall be completely removed from the surface of the road to the satisfaction of the Engineer and at Contractor's expense.

608.5.2 Payment

The quantities measured as determined above shall be paid for at the Contract unit price respectively for the pay items listed below, which price and payment shall constitute full compensation for furnishing and placing all materials including sampling, packing and testing at approved laboratory. The cost shall also include the preparation of the surface, and for all other costs necessary to complete the work as prescribed in this item.

Pay Item No.	Description	Unit of Measurement
608 a	Pavement Marking in non-reflective CR Paint for Lines of 15 cm width.	LM
608 b	Pavement Marking in non-reflective CR Paint for Lines of 20 cm width.	LM
608 c	Pavement Marking in non-reflective CR Paint for 4.0 M arrows.	NO
608 d	Pavement Marking in Reflective CR Paint for Lines of 15 cm width.	LM
608 e	Pavement Marking in Reflective CR Paint for Lines of 20 cm width.	LM
608 f	Pavement Marking in Reflective CR Paint for 4.0 M arrows.	NO
608 g	Pavement Marking in non-reflective TP Paint for Lines of 15 cm width.	LM
608 h	Pavement Marking in non-reflective TP Paint for Lines of 20 cm width.	LM
608 i	Pavement Marking in non-reflective TP Paint for 4.0 M arrows.	NO
608 j	Pavement Marking in Reflective TP Paint for Lines of 15 cm width.	LM

608 k	Pavement Marking in Reflective TP Paint for Lines of 20 cm width.	LM
608 l	Pavement Marking in Reflective TP Paint for 4.0 M arrows.	NO
608 m	Pavement Marking in non-reflective CR Paint for Stop	NO
608 n	Pavement Marking in non-reflective TP Paint for Stop	NO
608 o	Pavement Marking in Reflective CR Paint for Stop	NO
608 p	Pavement Marking in Reflective TP Paint for Stop	NO

SECTION 609 REFLECTORIZED PAVEMENT STUDS / MARKERS

609.1 DESCRIPTION

This item shall consist of furnishing and installing reflectorized pavement studs / markers, set into the traveled way of the type in accordance with the specifications and at the locations shown on the Drawings or as directed by the Engineer.

609.2 MATERIAL REQUIREMENTS

609.2.1 Reflectorized Studs

Reflectorized studs / markers shall be either Depressible type or Raised Profile type having the following characteristics. The contractor / manufacturer shall provide test reports from internationally recognized laboratories showing compliance with the applicable standards for the type of pavement stud to be used in the project.

(a) Aluminium Pavement Studs

Aluminium Pavement Studs shall be made from Aluminium Alloy Pressure Die Casted with size 100mm x 100mm and height of 20mm. Anchoring shank (optional) length shall be 50mm. Non-reflecting Aluminium Studs shall comply with BS 8442:2005. Reflectorized Aluminium Road Studs shall comply with ASTM D4280 and BS EN 1463. Fixing shall be done as per manufacturer's requirement.

(b) Depressible Type

The "Depressible" self cleaning type reflector shall comply with BS EN 1463 (Type-PB) – Permanent Road Studs. It shall be used where prolonged durability and very high reflectivity is required.

The base shall be formed of approved metal housing with adequate webbing or anchorage to ensure a firm key to the road when installed.

The pad shall be highly resilient specialist grade rubber compound that gives maximum impact resistance, depression durability and weather ability including adequate UV and chemical resistance. The rubber pad shall have a service life of at least five (5) years. The pad shall be so designed as to produce a self whipping action of the reflector when depressed.

The reflectors shall be made of impact and abrasion resisting glass or plastic and shall have minimum retro-reflectivity values corresponding to "Class PRP1 Type 2 or 3" of BS EN 1463 as follows:

Table 609-1: Minimum Retro-reflecting Values for the Reflectors

Entrance Angle β_H β_V = 0 Deg	Observation Angle α	Min R (mcd/lux)	
		Type 2	Type 3
15 Deg	2 Deg	2.5	1.5
10 Deg	1 Deg	25	10
5 Deg	0.3 Deg	220	150

The minimum night-time visibility requirements for each color of retro-reflector shall be based on the relevant number in the above table multiplied by the relevant color factor as follows:

Table 609-2: Color Factors

Color	Color Factor
White	1.0
Yellow	0.6
Amber	0.5
Red	0.2
Green	0.2

(c) Raised Profile Type

The `Raised Profile' reflectors shall conform to ASTM D-4280 or BS EN 1463 (Type- PA) and shall consist of materials with adequate water, chemical and UV resistance for intended use. Marker height shall not exceed 20.3mm and width shall not exceed 130mm.

The shell shall contain one or two prismatic reflectors each inclined at a maximum angle of forty five (45) degree to the horizontal and having an area not less than twenty (20) square cm or as indicated on the plans.

The markers / studs shall attain the following standards for their photometric and physical qualities:

(d) Reflector Strips for Concrete/Steel Guard Rails

Reflector Strips for Steel/Concrete guard rails will be hoist in metal box with adequate anchorage to fix it with Metal/Concrete guard rails. Photometric requirements shall be as mentioned in table 609-3 below. The quality of reflector shall be of engineering grade. The reflector sheet shall be of size 2" wide and 6" long in the colour as approved by the Engineer.

i) Photometric Requirements

The reflectors shall have the following minimum coefficient of luminous Intensity (R_I), with entrance angle component □**1** and rotation angle □ equal to Zero (0) Deg, when measured in accordance with ASTM D-4280 (Sec 9.1).

Table 609-3: Photometric Requirements

Entrance Angle Component □2	Observation Angle □	Min. Value R_I (mcd/lux)				
		White	Yellow	Red	Green	Blue
0 Deg	0.2 Deg	279	167	70	93	26
+20 Deg / -20 Deg	0.2 Deg	112	67	28	37	10

Failure of more than ten (10) % of the reflective faces shall be cause for rejection of the lot.

ii) Strength Requirement

The reflectors shall have a compressive strength of 2727 kg when tested in accordance with ASTM D-4280 (Sec 9.2.2) and flexural strength of 909 Kg when tested in accordance with ASTM D-4280 (Sec 9.2.1).

Failure in compressive strength shall constitute either breakage or deformation greater than 3.3mm of the marker up to 2727 kg load. Failure in flexure shall constitute breakage of marker up to 909 Kg load.

609.2.2 Epoxy Adhesive

When 'Raised Profile' type reflectors are used, a two-component epoxy adhesive conforming to Type-I (Rapid Setting) or Type-II (Standard Setting) as per AASHTO M-237 shall be applied to the stud for bonding to the pavement surface.

Adhesive primarily composed of asphaltic material shall not be used for bonding of studs to the pavement.

609.2.3 Cement Mortar

Cement mortar shall consist of one (1) part Ordinary Portland Cement to three (3) parts of fine aggregates.

609.3 CONSTRUCTION REQUIREMENTS

609.3.1 Depressible Type

The stud shall be installed into the pavement in accordance with the manufacturer's instructions but shall also comply with the following requirements, as applicable.

Cavities in the pavement shall be clearly cut to the dimension of the pavement stud and shall allow a clearance of one (1) cm around the stud base. The longitudinal center line axis of the cavity shall be the same as that required for the pavement stud when laid to correct line and direction.

The walls of the cavity shall be splayed back at an angle of approximately thirty (30) degree to the vertical to facilitate a "dove-tail" joint after the mortar has set.

The bottom of the cavity shall be leveled with asphalt concrete prior to placing the stud base, which shall be pounded into position with Pounder Foot attached to a pneumatic drill.

The depth of the cavity shall be such that when the stud base and reflectors have been installed the elevation of the floor of the lens socket shall not be greater than two (2) mm or less than one (1) mm above the pavement surface.

The stud shall be grouted into position with asphalt concrete containing fine aggregate only or with a cement mortar as described in Item 609.2.3 above when the studs are installed into a cement concrete pavement.

609.3.2 Raised Profile Type

The pavement studs shall be installed in accordance with the manufacturer's recommendations and instructions of the Engineer but shall also comply with the following requirements.

Road surface shall be free of oil, moisture and dirt before application of adhesive.

Epoxy adhesive, after application, shall have a thickness ranging from 3.2mm (1/8 inch) to 4.8mm (3/16 inch) and it shall be applied uniformly over an area with minimum plane dimensions protruding 13mm (1/2 inch) on all four sides of the marker / stud.

Traffic shall not be allowed on the road section where studs have been installed until the epoxy adhesive has set. Set time of adhesive shall be determined considering the prevailing temperature and type of epoxy used.

609.3.3 Reflector Strips for Concrete/Steel Guard Rails

The reflector strips shall be installed vertical on Concrete/Steel guard rails and spaced at distance given on the Drawings or as directed by the Engineer.
The method of installation will be such that it is fastened to steel guard rails through nut and bolts arrangement, whereas for Concrete surface proper hooks will be provided at two ends for rawlplug installation.
The angle on which the reflector strips are to be installed will be decided by the Engineer of the Project and they should be given a provision to deflect the reflector strips to an appropriate angle.

609.4 MEASUREMENT AND PAYMENT

609.4.1 Measurement

The quantity of reflectorized pavement studs to be paid for shall be the number of 'Depressible' or `Raised Profile' type provided and installed as mentioned above.

609.4.2 Payment

The quantities measured as described above shall be paid for at the contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which payment shall constitute full compensation for furnishing and placing all materials, excavating cavities, preparation of surfaces, applying adhesive and mortar, for all labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
609 a	Reflectorised aluminium pavement studs/cat eyes raised profile type - single)	NO
609 b	Reflectorised aluminium pavement studs/cat eyes raised profile type - double)	NO
609 c	Reflector strip for Steel/ Concrete guardrails.	NO
609 d	Reflectorised plastic pavement studs raised profile type - single)	NO
609 e	Reflectorised plastic pavement studs raised profile type - double)	NO

SECTION 610 PRECAST CONCRETE POSTS AND MARKERS

610.1 DESCRIPTION

The work shall consist of furnishing and placing precast concrete Kilometer, Ten Kilometer, Guide Posts and Right of Way Markers, complete including painting and lettering in accordance with the Drawings and specifications or as directed by the Engineer.

610.2 MATERIAL REQUIREMENT

610.2.1 Concrete

Precast concrete post and markers shall consist of Class A Concrete conforming to the requirements of Item 401 and to the lengths, shapes and other details shown on the Drawings.

610.2.2 Reinforcing Steel

Reinforcing steel shall conform to Item 404.

610.3 CONSTRUCTION REQUIREMENTS

(a) Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer.

Bedding shall be to section and dimension shown on the Drawings or as directed by the Engineer.

(b) Placing

The precast concrete posts and markers shall be set in two (2) cm of cement mortar to the level and grade as shown on the Drawings or as directed by the Engineer.

(c) Back-filling

After the placing of precast concrete posts and markers in the excavated areas and subsequent setting in with cement mortar, the same will be refilled to the required elevation with suitable earth or granular material, which shall be tamped in layers of not more than fifteen (15) centimeters each until firm and solid.

610.4 MEASUREMENT AND PAYMENT

610.4.1 Measurement

The quantity of each element to be paid for shall be the number of post and marker furnished and installed in place as per drawing or as directed by the Engineer.

610.4.2 **Payment**

The accepted quantities of posts and markers shall be paid for at the contract unit price per unit of measurement for the pay items listed below and shown in Bill of Quantities which price shall be compensation for furnishing, excavation, placing, erection, painting, lettering and for all costs including labour, tools, and incidentals necessary to complete the work prescribed in these items:

Pay Item No.	Description	Unit of Measurement
610 a	Right of Way Marker(rate of steel and concrete should be paid under relevant items of CSR).	NO
610 b	Kilometer Post (0.610x0.114x1.5 m) (rate of steel and concrete should be paid under relevant items of CSR)..	NO
610 c	Ten Kilometer Post(rate of steel and concrete should be paid under relevant items of CSR)..	NO

SECTION 611 F E N C I N G

611.1 DESCRIPTION

This work shall consist of constructing post and barbed wire fence or chain link fence in accordance with the details and at the locations shown on the Drawings or as directed by the Engineer.

611.2 MATERIAL REQUIREMENTS

611.2.1 Barbed Wire

Barbed wire shall conform to the requirements of ASTM A 121, Class I. The barbed wire shall consist of two (2) strands of twelve and half (12.5) gauge wire, twisted with two (2) points, fourteen (14) gauge barbs spaced 10 cm apart.

611.2.2 Chain Link Fabric

Chain link fabric shall be fabricated from ten (10) gauge galvanized wire conforming to AASHTO M 181 and shall be of the type shown in the Drawings. Before ordering the chain link fabric the Contractor shall submit a sample of the material to the Engineer for his approval.

611.2.3 Concrete Posts

Concrete posts shall be made from Class D1 concrete in accordance with Item 401.1.1. The posts shall be cast to the length shown on the detailed drawings and shall have a smooth surface finish.

611.2.4 Steel Posts

Steel posts shall be of the section as specified or as shown on the Drawings. The posts shall be of copper bearing steel and shall conform to the requirements of AASHTO M 183 for the grade specified.

611.2.5 Steel Reinforcement

Steel reinforcement for the concrete posts shall be deformed steel bars conforming to the provisions of Item 404.

611.2.6 Hardware

Nuts, bolts, washers and other associated hardware shall be galvanized after fabrication as specified in ASTM 153.

611.3 CONSTRUCTION REQUIREMENTS

611.3.1 Erection of Posts

The posts shall be erected vertically in position, inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the setting process of the concrete. The posts shall be erected to the height and location shown on the Drawings or as directed by the Engineer.

611.3.2 Installation of Chain Link Fabric

The chain link fabric shall be set to line and elevation and pulled tight between each post before spot welding or other method of fixing is carried out.

Where splicing of the fabric is necessary or at joints the lapping of the chain link fabric shall be a minimum of ten (10) cm and shall occur only at the concrete post. No horizontal splicing will be permitted.

The fabric shall be fixed to the concrete post as shown on the Drawings.

611.4 MEASUREMENT AND PAYMENT

611.4.1 Measurement

The quantity to be paid for shall be the number of linear meters of fencing erected in place and accepted, measured between the centres of the end posts.

611.4.2 Payment

The quantities measured as determined above shall be paid for at the contract unit price for the pay items listed below and shown in the Bill of Quantities which price and payment shall be full compensation for furnishing, placing, excavating, backfilling and erecting all posts for the installation, fixing and welding of the fabric and wire, and for all materials, labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
611 a	Galvanized wire mesh fence 1500mm high including Pre stressed and RCC posts complete in all respect as per M-2 standard	LM

SECTION 612 FURNISHING AND PLANTING TREES, SHRUBS AND GROUND COVER

612.1 DESCRIPTION

Under this work, the contractor shall furnish and plant trees, shrubs, vines, ground covers and other plants in addition to preparing and finishing planting beds and shall perform maintenance and planting operations in a workmanlike manner according to the provisions of these specifications and to accepted horticultural practice.

Trees, Shrubs, Vines, ground covers and other plants will herein be referred to collectively as "Plants" or "Plant Material".

The kinds, sizes and quantities of plants to be furnished and planted and the locations at which they are to be planted shall be as called for on the Drawings or as designated by the Engineer.

612.2 MATERIAL REQUIREMENTS

612.2.1 General

All plant material shall comply with the local laws with respect to inspection for plant diseases and infestation, and such inspection certificates as are required by law shall be filed with the Engineer's representative. All plants shall be first-class representative of their normal species or varieties and shall have average or normal well-developed branch or cane systems together with vigorous root systems. Plant cut back from larger sizes to meet specified sizes will not be acceptable. Plants shall be free from disfiguring knots, sun sealed, abrasions of bark, wind or freezing injury or other disfigurements. Plants shall show the appearance of normal health and vigour and shall bear evidence of proper top and root pruning. Unless otherwise indicated on the Drawings all plants shall be nursery grown.

612.2.2 Trees

Trees shall have straight trunks, well-branched with symmetrical top and intact leader. They shall have no cuts of limbs over two (2) centimeter in diameter which have not completely healed over. Each tree shall possess the characteristics for its variety and growth typical of such trees in the region.

612.2.3 Shrubs

Each shrub shall possess the characteristics of the variety and growth typical of such shrubs in the region.

612.2.4 Vines, Ground Cover and Other Plants

Vines, ground cover and other plants, such as perennials, which are furnished in pots or other containers and which have been acclimatised to outside conditions will be provided they are equal to field grown stock.

612.2.5 Collected Plants

Collected wood grown or natural seeding plants if permitted for use by indication on the Drawings, shall conform in quality, size and grade with the respective requirements herein given for nursery grown stock. In all cases such collected wood grown or natural seeding plants shall be of recognised first quality, clean sound stock free from decayed or decaying stumps and free from fire injury.

612.3 Handling & Transporting

All plants shall be dug, handled, prepared and packed for transportation to site with care and skill in accordance with recognized standard practice for the kind of plant concerned and in compliance with the following provisions from 612.3.1 to 612.3.4.

612.3.1 General

The root systems of all plants shall not be permitted to dry out any time and they shall not be exposed to artificial heat or to freezing temperatures. During transportation, all plants shall be packed adequately to insure protection from the sun, wind and climatic or seasonal injuries. Tarpaulins or other covers shall be placed over plants when they are transported by trucks or in open freight cars for considerable distances. All bare-root plants shall have their root systems protected by wet shingle, tow, moss or other suitable material. All earthballs shall be firm and intact and none shall be "made" balls. All balled and hessian covered plants shall at all times be handled by the ball, and not by the plant.

612.3.2 Trees

All evergreen trees shall be balled and hessian covered, except that small trees will be acceptable in suitable containers. The ball shall be firm and the hessian shall be sound at the time of delivering and placing the tree on the project.

Deciduous trees supplied in bare-root condition, shall have had their root systems puddled in a clay solution of sufficient density as to adhere to all parts of the root system. Deciduous trees may be supplied earth placed and hessian covered or in containers if the contractor so desires.

The head of each tree shall be carefully tied to prevent fracture of branches.

612.3.3 Shrubs

All evergreen shrubs shall be earth balled and hessian covered or in suitable containers as above provided for evergreen trees. Deciduous shrubs may be supplied bare root, earth balled and hessian covered or in suitable containers as provided above for deciduous trees.

When collected wood grown natural seeding stock or other non-nursery grown shrubs are permitted or called for on the Drawing or as directed by the Engineer, they will be specified as "Clumps" of various classifications. Collected plants shall be taken from soil, which has produced a fibrous root system typical of the nature of the plant. The clumps shall be dug with earth and incidental vegetation adhering to the roots of the soil or habit of the root growth in such that the roots are not adequately protected, the root system shall be unwrapped in hessian or other suitable material.

612.3.4 Vines, Ground Covers, Perennials Etc.

Vines, ground covers perennials and other similar plant material supplied in pots, tins and other suitable containers will be referred to collectively as pot grown plants. The root systems must be well protected and the plant supplied in accordance with the specification of quality and protection set forth above. Pot grown plants shall be well developed and sufficient roots to hold the earth together intact after removal from the containers and at the same time not be root bound.

612.4 LABELLING OF PLANT MATERIAL

Legible labels shall be attached to each plant, which is delivered to the site as a separate unit, and to each box, bundle, bale or container containing one or more plants. The labels shall give the approved horticultural name, size, age or other detailed data required to identify the plant as conforming to specification and, when not attached to separate plants, the label shall show the quantities of each specified plant contained in the box, bundle, bale or container.

612.5 INSPECTION AND REJECTION

All plants intended for use on the project shall be subject to inspection by the Engineer's Representative at any place and at any time. The Contractor shall inform the Engineer at the earliest practicable date as to the sources of plant materials to be furnished on the project, and shall give the Engineer at least 48 hours notice prior to delivery of plant material at the site of the planting operation.

After arrival at the site of the work and prior to the time of planting, each plant will be inspected by the Engineer's Representative for conformance to the Specification and Drawings, and such plants as do not conform thereto will be marked or otherwise identified as "rejected". All rejected plant material shall be removed from the project and shall be replaced by the Contractor with plant material conforming to all specified requirements, all at the Contractor's expense.

612.6 SUBSTITUTION OF PLANTS

No substitutions of plants material will be permitted unless it is proved to the satisfaction of the Engineer that specified plants are not available during the normal planting season occurring within the Contract period. If substitution of plant materials is thus permitted, it shall be made only with prior approval of the Engineer and shall be subject to adjustment, either for or against the Contractor, in such amount as the Engineer may consider to be fair and equitable.

612.7 TEMPORARY STORAGE

After being dug and prior to planting on the project, all plant material shall be properly protected against injury at all times. Plants which are not planted or which are not to be planted within one day after arrival on the project shall be given special protection as follows:

Bare-root plants shall be "heeled-in" in trenches with the bundles opened, the plants spaced separately, and all root covered and kept moist.

Earth-balled and hessian-covered plants shall have their balls protected by earth, straw or either suitable material which shall be kept damp or wet to prevent drying out of root systems.

All plants shall be protected from excessive heat or cold and shall be stored in a well ventilated and shaded place, protected from wind and sun.

612.8 CONSTRUCTION REQUIREMENTS

612.8.1 Layout of Planting Areas

Plant locations and outlines of planting areas shall be marked out and staked by the Contractor. The planting layouts will be subject to the approval of the Engineer prior to commencement of the planting operations.

612.8.2 Preparation of Areas for Planting

Areas on which planting is to be done shall be brought to pleasing contour and to the lines and grades directed by the Engineer, after which they shall be cultivated to a depth of fifteen (15) cm. All weeds and other vegetation growth, large clods, rocks and other debris encountered in the cultivating work, and any excess shall be removed and disposed of in a manner approved by the Engineer.

Excavation or pits for individual plants shall be made in accordance with provision (i) to (iv) as follow:

i) General

Topsoil shall be kept separate from subsoil and shall be rendered loose and friable. Alkaline soil, gravel, stones or other materials or matter encountered in the excavations and which are detrimental to plant growth shall be separated from the soil and disposed of at locations approved by the Engineer.

ii) Trees

Pits for trees shall be at least forty five (45) cm greater in dimension than the diameter of earth ball, or the spread root system of bare-root trees. Depths of pits for trees shall be not less than eighty (80) cm deep and as much deeper as may be necessary to provide a depth of at least twenty (20) cm below the bottom of earth ball or root system of the tree when placed at the proper level.

iii) Shrubs

Pits for shrubs shall be at least thirty (30) cm greater in dimension than the diameter of earth ball or the spread root system of bare-root shrubs. Depths of pits for shrubs shall be not less than thirty (30) cm and as much deeper as may be necessary to provide a depth of at least fifteen (15) cm below the bottom of the earth ball or root system of the shrub when placed at the proper level.

iv) Vines, Ground Covers and Other Plants

Pits, pockets or trenches for vines, ground covers and similar types of plant materials shall be of such dimensions as will provide space for the spread root systems of the plants. In general, the pits, pockets or trenches shall be wider and deeper than the actual space required, as above provided, by such amount as the Engineer may determine as being necessary to provide a space of not less than fifteen (15) cm around and beneath the root systems, in which space good quality topsoil and plant nutrient shall be in place at the time of planting.

612.8.3 Planting

All planting work, including backfilling, shall be performed by experienced workmen and in accordance with the recognised best horticultural practice. Plants shall be set plumb and at such a level of elevation that after settlement they will bear the same relation to the level of the surrounding ground as they bore to the ground from which they were dug. All plants shall be planted on and in good quality topsoil to which fertilizers and soil conditioners shall be added and uniformly mixed. The prepared topsoil used in filling under and around the plant and in backfilling the planting holes, pits or trenches shall be thoroughly and properly conditioned and settled by careful tamping and watering. For spring planting, a shallow saucer capable of holding water shall be formed about each plant on the surface of the completed backfill.

Earth-balled and hessian-covered plants shall have all cloth, ropes, etc. removed from the top of the earth balls, but no cloth shall be pulled out form under the balls. Prepared topsoil shall be carefully tamped around and under the base of each ball to fill all voids.

Bare-root plants shall have their roots spread out in a natural position and the prepared top soil shall be carefully placed under and among them to fill all voids. Any roots, which are broken or frayed shall be cleanly cut off from the plant.

In removing plants from containers, especially those of metal, care shall be taken to prevent disturbance of the root systems or ball of earth therein.

If topsoil of suitable quality is not obtainable for planting area preparation in sufficient quantity for the planting work, the Contractor shall make up any deficiency. Insofar as such is available and can be taken without detriment to the highway development, the Contractor will be permitted to obtain suitable topsoil from areas within the jurisdiction of the Employer, subject to the directions of the Engineer as to the location, depth, line and grade to which excavation thereof shall be made. The right to take materials from sources not under the jurisdiction of the Employer shall be acquired by the Contractor at his own expense.

Subsoil, and topsoil in excess of the amounts required for filling and backfilling work on the planting areas shall be disposed of by the contractor in a manner satisfactory to the Engineer.

612.8.4 Pruning, Guying and Staking

After being planted, all plant materials shall be pruned in conformance to the best horticultural practice appropriate to the type of plant. Pruning shall be such as will remove injured twigs and branches and as will compensate for loss of roots during planting operations. Pruning shall produce clean cuts without bruising or tearing the bark, shall be in living wood and where the wound can heal over properly. Cuts over 2 cm in diameter shall be painted with an approved tree-wound paint.

All deciduous trees over two (2) meter in height shall be staked or guyed at time of planting. The stake shall be placed in the plant excavation and driven securely into the ground prior to planting operations. The tree shall be placed not to exceed ten (10) cm from the stake and fastened tightly to the stake at a point approximately two thirds the height of the tree by means of two and half (2.5) mm wire. At the point of contact with the tree, the wire shall be covered with a length of rubber hose adequate to protect the bark from chafing and injury. The tie wire shall cross between the tree and stake and be securely fixed at the specified height.

Deciduous trees over two and half (2.1/2) M high, but less than 4 M high, shall be staked in a similar manner. In all cases, the stakes shall be cut off to present a uniformly pleasing appearance as directed by the Engineer.

Trees of four (4) M or greater height shall be guyed with guy cables, each consisting of two (2) strands of two and half (2.5) mm or heavier wire extending from approximately two thirds the height of the tree to a stake or deadman anchored securely in the ground at a distance from the trunk of about three-quarters the height of fastening. The tree shall be protected by rubber hose or similar means. Evergreen trees or other hessian covered shrubs over half (1/2) M in height shall also be guyed with three (3) cables in a similar manner.

612.8.5 Cultivation of Planting Areas

An area having a diameter of not less than Ninety (90) cm and lying around each planted tree and shrub and an area having a diameter of not less than 30 cm and lying around each planted vine or ground cover shall be loosened and brought to friable condition for a depth of not less than 8 cm. Where plant materials are planted in groups in which the plants are so closely spaced as to justify treatment of the area as a unit, the entire area so occupied and extending 60 cm beyond the outer ends of the branches or canes shall be cultivated as above provided.

Prior to any planting operations, the planting areas shall be brought to the lines, grades and cross-sections indicated on the Drawings or as directed by the Engineer. If the areas are to have mulching material placed thereon, as indicated on the Drawings, grades shall be adjusted and established to provide space for the mulch. At the edges of walks, pavements and driveways the finished surface shall be approximately three (3) cm below the surfaces thereof. At edges of lawn areas, the finished surface shall be approximately five (5) cm above the normal height of grass. The edges of adjoining lawn shall be neatly trimmed with a sharp edging tool.

The cultivating work shall include the removal of weeds, the breaking up or removing of clods, the removal of objectionable stones, litter and debris, as well as the removal and disposal of excess soil. Disposal of these materials shall be in a manner satisfactory to the Engineer.

If mulching is required, as indicated on the Drawings the planting areas may be left in a reasonably smooth condition and with irregularities in surface grade and cross-section not exceeding three (3) cm.

612.8.6 Mulching

Planting areas shall be mulched after cultivation with materials of the approved quality and placed to the depths indicated on the Drawings. Mulch materials shall be spread uniformly over the areas to be mulched and shall be finished to a smooth and uniform surface.

612.8.7 Fertilizers and Soil Conditioners

Fertilizers and soil conditioners shall be mixed with topsoil used in the planting operations and used elsewhere as directed by the Engineer. Mixing of these materials with soil, mulch and other materials shall be thorough and complete. They shall be incorporated in the work as directed by the Engineer.

Fertilizer shall consist of an approved compound containing not less then:

10 percent Nitrogen
15 percent Phosphoric Acid
10 percent Potash
or similar approved composition

The Contractor may add with the approval of the Engineer any additional plant nutrients, which he considers the constitution of the soil to warrant.

612.8.8 Maintenance and Protection

Until such time as all work to be done in the Contract is completed by the Contractor and has been finally accepted by the Engineer, the Contractor shall maintain all plant materials and all planting areas efficiently. Maintenance shall consist of keeping plants in a healthy, growing condition by watering, pruning, spraying and other necessary operations. Maintenance shall also include the keeping of planting areas free from weeds, grass, litter and debris, as well as keeping the area smooth, neat and attractive.

In the event of an infestation from insects or disease, the plants shall be treated by preventive or remedial measures approved for good horticultural practice.

If "heeled-in" plant materials have to be held over until a later planting season, such plant materials shall be lifted and replanted in nursery rows. Such emergency storage and maintenance of held-over stock shall be at the sole risk and expense of the Contractor.

All plant and material shall be protected from stray animals or theft or damage by any element during the specified period of maintenance at the expense of the contractor.

612.8.9 Guarantee and Replacement

Until such time as all work to be done under the Contract is completed by the Contractor and during a specified maintenance period after acceptance of the planting, the life and satisfactory condition of all plants furnished by the Contractor shall be guaranteed by the Contractor.

During this period, all plants, which, in the opinion of the Engineer are in an unhealthy or badly impaired condition, shall be replaced with satisfactory material. After the conclusion of the planting operation and prior to the

completion of all normal work to determine the condition of the plantings, all plants then not in a healthy growing condition will be noted for replacement and shall be promptly removed by the Contractor. As soon as seasonal conditions permit, all plants to be replaced shall be replaced by the Contractor with the same kinds and sizes and in the same manner as originally specified and at no extra cost to the Employer.

612.9 MEASUREMENT AND PAYMENT

612.9.1 Measurement

The quantity to be paid for at the applicable price tendered for a given type of plant material shall be the number of plants of that type furnished in place as specified and finally accepted by the Engineer.

No separate payment will be made for the furnishing of fertilizers, mulching materials and soil conditioners.

612.9.2 Payment

Payment for the furnishing and planting of trees, shrubs, vines, ground cover and other plant materials will be made at the price tendered for each for "furnishing and planting" the various types of plants, as set forth in this specification and on the Drawings.

The price tendered for each for the specified and listed pay items tendered shall be understood to cover and include payment for all labour, materials, planting, maintenance, replacement work, transportation and placing of fertilizers, mulching materials and soil conditioners, and the performance of all other items of work necessary to complete the work in accordance with the specification, and for which separate payment is not specifically provided.

Pay Item No.	Description	Unit of Measurement
612 a	Furnishing and planting of trees including maintenance period of two years.	NO

SECTION 613 SPRIGGING AND SODDING

613.1 DESCRIPTION

These works shall consist of furnishing top soil and planting sprigs or laying grass sods in accordance with the specifications, at the location shown on the drawings, or as required by the Engineer.

613.2 MATERIAL REQUIREMENTS

613.2.1 Top Soil

Top soil furnished by the Contractor shall consist of a natural friable surface soil without admixture of undesirable subsoil, refuse, or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 5 cm in diameter, noxious woods, tall grass, bush sticks, stubble, or other litter, and shall have been cultivated from a healthy growth of crops, grasses, trees or other vegetation that is free draining and non-toxic.

613.2.2 Sprigs

Sprigs shall be healthy living stems (stolons or rhizomes) with attached roots of perennial turf-forming grasses harvested with adhering soil, and obtained from approved sources in the locality of the work where the sod is dense and well rooted. The presence of detrimental materials will be cause for rejection.

613.2.3 Grass Sod

The sod shall consist of a healthy, dense and well rooted growth of living grass.

The grass sod shall be cut into uniform squares approximately 30 cm by 30 cm or in rolls of uniform width of approximately 39 cm and shall have a minimum thickness of 5 cm (excluding grass blades).

613.3 CONSTRUCTION REQUIREMENTS

613.3.1 Top Soil

a) Source of Material

The Contractor shall notify the Engineer at least 5 days before he intends to start top soil stripping operations. After inspection and approval by the Engineer and prior to stripping any top soil, the Contractor shall remove noxious weeds and tall grass, bush roots and stones larger than 5 cm in diameter.

b) Placing Top Soil

The top soil shall be evenly spread on the designated areas to the line and slope if shown on the drawings and compacted to a depth of not less than 10 cm. Spreading shall not be done when the ground topsoil is excessively wet, or otherwise in a condition detrimental to the work. The roadway surfaces shall be kept clean during hauling and spreading operations.

After spreading has been completed, large clods, stones, roots, stumps and other loose lying material shall be raked up and removed. Any erosion, irregularities of grade or other incidental damage to the surface of top soil prior to the planting of springs or laying of grass sods shall be required to the Engineer's satisfaction.

613.3.2 Sprigging

a) Harvesting Sprigs

The Contractor shall obtain the Engineer's approval of his source of springs and shall notify the Engineer at least 5 days before the sprigs are to be harvested.

Sprigs that have dried out or are otherwise damaged during harvesting or delivery shall be rejected.

b) Planting Sprigs

Spriggings shall not be done during windy weather, or when the ground is dry, excessively wet, or otherwise un-tillable. If the soil is not moist when the sprigs are being set, water shall be applied until the soil is moist and in a workable condition. One or more of the following methods shall be used, whichever is shown on the drawings:

i) Row sprigging Furrows shall be opened along the approximate contour of slopes at the spacing and depth indicated on the drawings. Sprigs shall be placed at intervals not exceeding 15 cm in a continuous row in the open furrow, & shall be covered immediately.

ii) Spot sprigging spot sprigging shall be performed as specified under row sprigging except that, instead of planting in continuous rows, groups of four sprigs or more shall be spaced 50 cm apart in the rows.

c) Maintenance of Sprigged Areas

The Contractor shall regularly water and maintain sprigged areas in a satisfactory condition for the duration of the contract and until final acceptance of the work by the Engineer.

613.3.3 Sodding

a) Preparation of the Earth Bed

The Surface of the top soil on the area to be sodded shall be loosened and brought to a reasonably fine texture to a depth of approximately 2.5 cm.

b) Placing the Sod

The earth bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after having been cut.

Unless otherwise required, the sod on slopes shall be laid horizontally, beginning at the bottom of the slopes and working upwards. When placing sod scour checks or similar construction, the length of the strips shall be laid at right angles to the direction of flow of the water.

As the sod is being laid, it shall be lightly tamped with suitable wooden tampers, sufficiently to set or press the sod into the underlying soil.

At points where it is anticipated that water may flow over a sodded area, the upper edges of the sod strips (e.g., top of embankment) shall be turned into the soil to be below the adjacent area, and a layer of earth shall be placed over this juncture, and thoroughly compacted.

At the limits of sods areas, the end strips shall be turned in and treated as described above.

c) Staking the Sod

On all slopes steeper than one meter vertical to four meters horizontal the sod shall be pegged with stakes, 20-30 cm in length, spaced as needed by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until flush with bottom of the grass blades.

d) Top Dressing

After the staking has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer of top soil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

e) Maintenance of Sodded Areas

The Contractor shall regularly water and maintain sodded areas in a satisfactory condition for the duration of the Contract and until final acceptance of the work by the Engineer.

613.4 MEASUREMENT AND PAYMENT

613.4.1 Measurement

The work of sprigging, sodding and top soiling shall each be measured by the square meter, which has been planted or placed in accordance with these specifications and accepted.

The top soil to be measured for payment shall be that quantity which exceeds the amount in Item 103 for “Stripping”.

613.4.2 Payment

The quantity measured as prescribed above shall be paid for at the contract unit price for the pay items, Listed below and shown in the Bill of Quantities, which payment shall be full compensation for furnishing all materials, water, labor, equipment, tools, transport and all costs necessary to complete the work as prescribed in the above items.

Pay Item No.	Description	Unit of Measurement
613 a	Sprigging	SM
613 b	Sodding	SM
613 c	Top Soil	SM

SECTION 614 COLD APPLIED, RESIN BASED HIGH FRICTION ROAD SURFACING

614.1 DESCRIPTION

The works consist of Cold-applied thermoset resin-based road surfacing material, designed to provide high skid resistance and colour demarcation. High friction (or antiskid) properties are achieved and maintained throughout the service life by the use of high PSV calcined bauxite aggregates. By providing high friction, anti-skid contact with vehicle tyres, braking is achieved more effectively, reducing the risk of skidding and loss of vehicle control.

614.2 MATERIAL REQUIREMENTS

614.2.1 Primer:
Primer shall be as per manufacturer's recommendations and shall be used where required as per existing substrate conditions.

614.2.2 Binder:
Binder shall be as per manufacturer's recommendations and shall consist of binder resin, BPO catalyst, thixotrope and, where required, pigment powder or paste.

614.2.3 Aggregates:
All aggregates shall be as per manufacturer's recommendations and must be clean, dry and free from excessive dust. The size of calcined bauxite aggregates suitable for use is 1 – 3 mm.

614.3 FEATURES

The material used for surfacing and the finished surfacing shall have following features:

- Meeting requirements as per BBA/HAPAS Type 1.
- Quick curing at low temperatures.
- Excellent abrasion, impact and chemical resistance
- Resistant to extremes of temperature.
- Flexible.
- Enhanced adhesion to asphalt.
- Resistant to UV, weathering and age embrittlement.
- Resistant to de-bonding.
- Aesthetic appearance (various colours).
- Low application temperature.
- Suitable for use in fire hazard zones.
- Long service life.

614.4 APPLICATION AREAS

Suitability of application of High Friction Surfacing shall include the following areas:
Road carriageways, intersections, junctions, pedestrian crossings, roundabouts, traffic lights, sharp or adverse cambers on bends, cycle lanes, footbridges, subways, pavements, car parks, airports, railway platforms, bus stations, ports, dockyards or ship decks, , car park ramps and any potentially hazardous road surface, leisure areas and all areas where colour demarcation is required.

614.5 TECHNICAL PROPERTIES

Technical properties of the Skid Resistant Surface and its constituents shall be as follows:

S. No.	Description	Value
1.	Required film thickness	1.2 mm.
2.	Specific gravity (mixed resin)	0.98 kg/ L
3.	Pot Life (approximate) (at 20℃)	20 min
4.	Initial set (at 20℃)	One hour
5.	Open to traffic (at 20℃)	Two hours
6.	Tensile strength (at 23℃)	10 N/mm²
7.	Elongation at break (at 23℃)	80%
8.	Tensile adhesion (at 20℃, typically).	2.5 N/mm²
9.	Tensile Adhesion Requirement	Concrete > 1.0 MPa Asphalt > 0.5 MPa
10.	Skid resistance value: Using traffic grade calcined bauxite aggregate	≥ 80
11.	Polished Stone Value (PSV) as per BS EN 13043	≥ 70
12.	Aggregate Abrasion Value (AAV) as per BS EN 13043	≤ 10

For determination of setting and curing times at different site temperatures, manufacturer's recommendations shall be followed.

614.6 CONSTRUCTION REQUIREMENTS

Following construction requirements shall be followed in addition to any further requirements specified by the manufacturer.

1. At least 28 days shall be allowed prior to applying Resin to new asphalt.
2. Resin must be applied to surfaces which are clean and dry. Time shall be allocated to adequately prepare the substrate prior to the application of Resin. Edges, drain covers etc shall be masked.
3. The substrate must be sound, as Resin does not provide any structural strength. Repairs should be carried out in advance to ensure an even surface prior to the installation of Resin. The surface shall be pre-primed with suitable Primer where necessary.
4. Mixing shall be carried out using a drill and paddle. The mix shall then spread over the application area using a squeegee.
5. Allow the resin to self-level for a few minutes and then broadcast the aggregates on to the wet film until the surface is fully blinded.
6. Minimum uniform resin film thickness of 1.2 mm shall be achieved in addition to the material required for filling the surface texture of the substrate. To achieve this, Resin application rates shall be as per manufacturer's recommendations
7. Whilst curing, any masking tape should be removed.
8. Wet Resin shall be fully blinded with aggregate at 8 – 10 kg/m². Following curing, surface shall be swept to retain 5 – 6 kg/m².
9. The completed surface shall be allowed to cure before sweeping off the excess aggregate which can be re-used if clean and dry.

614.7 MEASUREMENT AND PAYMENT

614.7.1 Measurement

The work of High Friction Surface shall each be measured by the square meter which has been placed in accordance with these specifications and accepted.

614.7.2 Payment

The quantity measured as prescribed above shall be paid for at the contract unit price for the pay items, listed below and shown in the Bill of Quantities, which payment shall be full compensation for furnishing all materials, labor, equipment, tools, transport and all costs necessary to complete the work as prescribed in the above items.

Pay Item No.	Description	Unit of Measurement
614 a	Cold Applied Resin Based High Friction Surface	SM

MISCELLANEOUS

SECTION 701 PROVISION OF SURVEY TEAMS AND INSTRUMENTS

701.1 DESCRIPTION

The contractor shall provide necessary surveying staff and surveying equipment to the Engineer for conducting necessary survey work in connection with checking or establishing line, level, control and quantification of different items of work.

701.2 EXTENT OF PROVISION AND GENERAL REQUIREMENT

Engineer shall specify the quality, type and number of survey equipment, in Special Provision. Engineer shall also specify the number and designation of survey staff to be provided under this item.

701.3 MEASUREMENT AND PAYMENT

701.3.1 Measurement

The quantities to be paid for under this item of work shall be at the contract unit price.

701.3.2 Payment

Payment shall constitute full compensation for all costs of furnishing survey teams and necessary labour, materials, equipment and its maintenance and incidentals, for the proper completion of the work as directed by the Engineer in the Special Provision. If the survey instruments are provided against a normal B.O.Q. item then these will remain the property of contractor at the end of the project. However if survey instruments are supplied against Provisional Sum item, then these will remain client's property and shall be handed over to the client at the end of the projects.

SECTION 702 PROVIDE, EQUIP AND MAINTAIN OFFICE FACILITY AND RESIDENCE FOR THE ENGINEER (BASE CAMP FACILITY) AND CLIENT'S REPRESENTATIVE.

702.1 DESCRIPTION

The contractor shall provide and properly maintain, for the duration of the work, office and residential facilities for the Engineer, his staff and Client's representative. The site shall be located as shown on the plans or as directed by the Engineer. Preferably, location of this office facility shall be at a central location of the project site near to contractor's office and laboratory and shall remain at the exclusive use of Engineer and his staff and Client's representative. The office facility shall be constructed, equipped and furnished as shown in the Special Provisions and drawings.

702.2 MAINTENANCE REQUIREMENTS

The Contractor shall provide necessary Janitorial Services and supply for the above official accommodation such as cleaning, window washing etc. Air-conditioning, heating and ventilation shall also be provided as per special provisions. Contractor shall provide security services for base camp around the clock to the satisfaction of the Engineer. Maintenance or replacements of worn out or broken equipment or furniture shall be done by the contractor against item of maintenance.

All charges for installation and maintenance of utilities such as water, gas and electricity shall be borne by the contractor.

If the operations of the Contractor are such that additions to the Engineer's staff are required, the contractor shall provide additional facilities and equipment as directed by the Engineer. The cost of the same shall be the responsibility of the Contractor and shall be considered subsidiary to all other pay items listed in the Bill of Quantities, and paid on proportional basis.

702.3 BUILDING SITE ACQUISITION AND OWNER-SHIP

The Client will secure and obtain the land required for the Engineer's office and his representative and will make said land available to the Contractor for construction purposes after signing of the contract.

The above described accommodation shall be constructed within three months after the availability of land, however temporary office accommodation of equal area shall be provided by the contractor elsewhere, during the construction of Engineer's offices and residences without any extra charge, however maintenance of such temporary accommodation shall be paid at the quoted rate.

After completion of the contract, buildings, fixtures and furniture shall be the property of the Client.

In order to cater for the offices and residential accommodations, for project of small duration, contractor shall provide temporary office accommodation as provided in the Special Provisions.

702.4 MEASUREMENT AND PAYMENT

702.4.1 Measurement

Work under this item shall be measured in three portions:

i) Provide and equip Engineer's and Client's office and Residence to be measured for payment as Lump-sum soon after its completion.

ii) Furnish Engineer's & Client's office & residence.

iii) Maintain Engineer's office and Residence to be measured for the duration of the contract.

702.4.2 Payment

The quantity to be paid for under this item of work shall be at the contract price quoted in the Bill of Quantities which price and payment shall constitute full compensation for all costs of furnishing labour, materials, equipment and incidentals for the proper completion of the work prescribed in the specifications, drawings and Special Provisions. In case if furnishing is provided against a normal B.O.Q. item then it will become the property of contractor at the end of the project. However, if furnishings are supplied against a Provisional Sum item, then these will become the property of the Client.

SECTION 703 PROVIDE, EQUIP AND MAINTAIN LABORATORY FOR THE PROJECT

703.1 DESCRIPTION

This work shall include the construction of Laboratory complete and ready for use, with all necessary furnishing of equipments, utilities, installations and access/service roads, all to the satisfaction of the Engineer as shown on the drawings and mentioned in the Special Provisions.

703.2 GENERAL REQUIREMENTS

The furnishing of equipment shall ensure conduction of all tests related to construction items described under relative material requirement clause. In case if any test required for testing of material cannot be performed in the project laboratory, the Engineer may authorize such a test to be carried out at the cost of contractor, at any other laboratory. The Contractor shall provide at no cost to the Engineer, technicians and helpers in the number deemed necessary by the Engineer, to assist in the operation of the laboratories as required by the Contractor's proposed programme of work. Technicians and helpers once assigned to the laboratories may be removed by the Contractor only with the approval of the Engineer.

The Contractor shall maintain the laboratory equipment, apparatus and supplies necessary to permit execution of all standard tests required by the specifications. Lists of specific laboratory equipment noted in the special provisions are intended as an aid to the contractor and should not be construed as a binding list nor as a recommendation to purchase from a specific manufacturer. The Contractor shall submit to the Engineer for his approval at his earliest, a complete listing of the equipment, apparatus and supplies he proposes to furnish for the laboratory. The list shall include the manufacturer's name and descriptive literature.

Lab. Equipment, fixtures & furniture shall remain the property of the contractor after completion of the project, however laboratory building, shall be handed over to the client which shall be constructed on the land made available by the client as per item 702.3.

703.3 FACILITY OF THE MATERIAL TESTING

Material testing facilities (Laboratory) as described above shall be completed within the mobilization period. In case of delay in providing such a facility, as an interim arrangement, temporary facilities of testing material shall be provided as agreed by the Engineer. Contractor may be paid for maintenance of temporary laboratory, provided such facilities are acceptable to the Engineer. Contractor shall also bear all extra expenses for conduction of tests in temporary arrangement as per Engineer’s requirements.

703.4 WEATHER RECORDING EQUIPMENT

The contractor shall furnish and maintain in good working order for the duration of the contract, instruments and their necessary appurtenances to be used by the Engineer in recording weather data. These instruments shall be installed at a suitable place as directed by the Engineer. The instruments will be of the latest model subject to approval of the Engineer including:

i.) One (1) rain gauge
ii.) One (1) thermometer
iii.) One (1) recording barometer.
iv.) One (1) maximum - minimum thermometer
v.) One (1) wind speed gauge (optional – as per requirement of the project and decision of the Engineer)

703.5 MEASUREMENT AND PAYMENT

703.5.1 Measurement

Work under this item shall be measured in three (3) portions:

i) Provide Material Testing Laboratory, to be measured for payment as Lump-sum soon after its completion.

ii) Equip & Furnish Project Laboratory to be measured as Lump-sum item.

iii) Maintain Laboratory, to be measured for the duration of the contract.

703.5.2 Payment

The quantities under this item of work shall be paid at the contract price indicated in the Bill of Quantities which price and payment shall constitute full compensation for all costs of furnishing labour, materials, equipment and incidentals for the proper completion of the work indicated in these specifications and specified on the drawings and Special Provision.

SECTION 704 MAINTENANCE OF WORKS FOR ONE YEAR AFTER COMPLETION, DEFECT LIABILITY PERIOD (PERIOD OF MAINTENANCE)

704.1 DESCRIPTION

This work shall consist of execution of all such work of repair, amendment, reconstruction, rectification and making good defects, imperfections, shrinkage or other faults as may be required of the Contractor, in writing by the Engineer during the Period of Maintenance, or within fourteen (14) days after its expiration, as a result of an inspection made by or on behalf of the Employer. Period of Maintenance as defined herein is one year beginning the day following the receipt by the Contractor of the Certificate of Completion issued by the Employer.

704.2 MATERIALS

All materials to be used for maintenance of works shall conform to the requirements of applicable sections of this specification in the particular item of work involved.

704.3 CONSTRUCTION REQUIREMENTS

All repair/remedial work shall be carried out by the Contractor at his own expense if the necessity thereof shall, in the opinion of the Engineer, be due to the use of materials or workmanship not in accordance with the Contract, or the neglect or failure on the part of the Contractor to comply with any obligation, expressed or implied, on the Contractor's part under the contract.

704.4 MEASUREMENT AND PAYMENT

704.4.1 Measurement

Any maintenance work which become necessary due to use of bad quality material or bad workmanship or which is required to repair normal wear and tear shall not be measured for payment.

However any special work during maintenance period if carried out at the written instruction of the Engineer the same shall be measured and paid under applicable item of work of the BOQ.

704.4.2 Payment

The payment for this item for the first year shall be deemed to have been included in rates for different items of work and no payment on account of maintenance shall be made under this item.

However, in case the Employer requires the maintenance of project for more than one year, B.O.Q. shall show a separate item 704, and contractor shall quote the rate for such provision.

SECTION 705 TEMPORARY ROAD WORKS FOR TRAFFIC DIVERSION

705.1 DESCRIPTION

The Contractor is allowed to carry out rehabilitation work on half carriage way and direct the traffic on the other half. However, if he opts to divert the traffic on temporary road for ease in construction, he shall provide, maintain and remove on completion of the works for which they are required, all Temporary Road Works such as, detours, sleeper tracks over unstable ground and bridges over streams and shall make them safe and suitable in every respect for maintaining two way diverted traffic. Such temporary diversion structures shall be constructed to the satisfaction of the Engineer.

705.2 MATERIALS

Materials used in the construction of Temporary Road Works shall provide reasonably smooth and strong surface to carry the traffic, as approved by the Engineer.

705.3 CONSTRUCTION AND MAINTENANCE REQUIREMENTS

Before constructing Temporary Road works, the Contractor shall make all necessary arrangements, including payment if required, with the public authorities or land owners concerned, for the use of the land and he shall also obtain the approval of the Engineer. Such approval will not, however, relieve the Contractor of his contractual obligations. Upon completion of the Works, the Contractor shall clean up and restore the land to the satisfaction of the Engineer or the landowner concerned, which shall be very near to original condition, unless otherwise allowed in writing.

705.3.1 Construction requirements for Temporary Road

Works shall be carried out by the contractor as per requirement of items used in construction or as directed by the Engineer. Temporary road shall have properly designed vertical and horizontal curves and adequate passing and stopping sight distances as per traffic requirements. Length of diversion shall not exceed more than 20 percent of project length unless otherwise authorised by Engineer.

705.3.2 Maintenance of Temporary Road

Works shall be performed periodically and to such an extent as to cause no delays or interruption to the normal flow of traffic.

Such work shall include, but not limited to, immediate repair of potholes, regular grading to maintain smoothness of the road surface, cleaning of culverts to ensure proper drainage, repair of damaged portions which may affect traffic flow.

705.4 MEASUREMENT AND PAYMENT

705.4.1 Measurement

No measurement shall be made for providing, maintaining, removal and disposal of temporary road for diversion of traffic in case, if it is required, to divert the traffic for ease in road or culvert construction, as half lane road construction is allowed on the project.

However, in case of bridge construction, the provision and maintenance of temporary road shall be measured as under, where as removal and disposal of temporary road shall not be measured for payment.

a) Construction of temporary road

Contractor shall submit the proposal of construction to the Engineer. Engineer may amend or approve the proposal of the contractor, which will then be authorised for construction on rate already quoted by the contractor

b) Maintenance of temporary road

Contractor shall maintain the temporary road as directed by the Engineer, measurement shall be made proportionate to the road completed & opened for traffic, approved for maintenance period.

705.4.2 Payment

Payment for provision of temporary road diversion for bridges shall be made under applicable items of works of the B.O.Q., whereas payment for maintenance of temporary road diversion for bridges shall be made under this item as measured under item 705.4.1(b).

SECTION 706 CONTROL AND PROTECTION OF TRAFFIC

706.1 DESCRIPTION

706.1.1 General

The Contractor shall keep open to traffic half a portion of any existing road during the performance of the rehabilitation work on the other half, provided that when such maintenance of traffic is not possible for any reason the contractor will construct a temporary road as provided under item 705.

The Contractor shall take necessary care at all times to ensure the convenience and safety of residents along and adjacent to the Highway.

Any failure of the Contractor in the performance of these works will entitle the Engineer to carry out such work as he deems to be necessary and to charge the Contractor with the full cost thereof, which sum will be deducted from any money due or which may become due to the Contractor under the Contract.

706.1.2 Temporary Traffic Control

In order to facilitate traffic movement through or around the works, or wherever ordered by the Engineer, the Contractor shall erect and maintain at prescribed points on the works and at the approaches to the work, traffic signs, signals, illumination, flares, barricades and other facilities as required by the Engineer for the direction and control of traffic.

Where required, or where directed by the Engineer, the Contractor shall furnish and station competent flagmen, whose sole duty shall consist of directing the movement of traffic through or around the work.

706.1.3 Single-Lane Traffic Control

In all cases where single-lane traffic becomes necessary over a particular length of the works or over the approaches thereto, the Contractor, in maintaining through traffic, shall provide a single lane at least three and a half (3.5) meters wide on the roadway or embankment to be kept open to traffic.

The Contractor shall so conduct his operations as to offer the least possible obstruction, in-convenience and delay to traffic and shall be responsible for the adequate control of the traffic using the width, of single lane above specified.

At places where such single-lane traffic is in operation, and when ordered by the Engineer, the movement of the Contractor's equipment from one portion of the work to another shall be subject to such single-lane traffic control. Spillage resulting from haulage operations along or across the roadway shall be removed immediately at the Contractor's expense.

706.1.4 Project Information Signs

The contractor shall within the mobilization period, erect project information signs at all main roads crossing the project area and at the beginning and end of the contract. The size of the project information signs and the message thereon shall be determined by the Engineer.

706.2 MATERIALS

Materials of road posts, hazard markers, warning tapes, traffic signs, flashing amber lights, signals, barricades, diversion cones, big cones, bollards, detours (Chevron) etc; shall conform to current BS or ASTM standards or as approved by the Engineer.

706.3 CONSTRUCTION REQUIREMENTS

Traffic signs, signals, barricades, warning tapes road posts and hazard markers, cones, bollards etc. shall be so placed as to be easily and opportunely visible to oncoming traffic to ensure drivers will know immediately what instructions they are to follow.

706.4 MEASUREMENT AND PAYMENT

706.4.1 Measurement

This item shall be measured in number of months during which the traffic is properly maintained by the contractor by providing all signs, signals, illumination, barricades etc. around the clock and necessary manpower / flagmen as per requirement of the Engineer.

706.4.2 Payment

Payment for the maintenance of Traffic as measured above shall be made under the applicable item of the work of BOQ for the number of months during which satisfactory performance is verified by the Engineer.

SECTION 707 REMOVAL / RELOCATION OF UTILITIES

707.1 DESCRIPTION

This work shall consist of carrying out relocation of various types of services falling within the Right of Way. The quantum of work shall be established by the design consultant and elaborated in the Special Provisions or as directed by the Engineer.

707.2 MATERIAL REQUIREMENTS

All materials, if required for the relocation of services shall conform to the Specifications of the relative department whose utilities are being shifted.

707.3 CONSTRUCTION REQUIREMENTS

The construction requirement such as alignment, level and general workmanship shall conform to the applicable requirements of relative departments.

707.4 MEASUREMENT AND PAYMENT

707.4.1 Measurement

The quantity of each item for which utilities have been relocated shall be measured in the unit as approved by the Engineer or as designated in the Special Provisions.

707.4.2 Payment

The accepted quantity measured as applicable to each item shall be paid on the unit rate as quoted / agreed with the contractor for each item.

This payment shall constitute full compensation for any design work, coordination with relative department, furnishing of materials and installing or relocation as per requirement of the relative department, which shall also include all labour, equipment, tool and incidental necessary to complete the item.

SECTION 708 CONSTRUCTION SITE SAFETY

708.1 DESCRIPTION

In this section, health and safety aspects of various areas of construction, precautionary measures and possible solutions to some of the encountered problems will be discussed. Detailed regulations shall be adopted from Occupational Health and Safety Administration (USA) Regulations (Parts 1910 & 1926).

708.2 CONSTRUCTION REQUIREMENTS

708.2.1 Personal Protective Equipment (PPE)

i. Following PPE shall be mandatory at all construction sites and shall be worn by all persons entering the site whatever the designation:
   a. Hard Hat
   b. Suitable Clothing and Hard Sole Safety Shoes
   c. Safety Vest
   d. Safety Glasses

ii. Following additional PPE shall be required as per job requirement:
   a. Hearing Protection
   b. Respiratory Protection (Dust Mask)
   c. Hand Protection (Gloves)
   d. Face Shield for flying debris.
   e. Welding Shield
   f. Safety Harness

708.2.2 Excavation and Trenches

Excavations of all types require barricading and hand railing of substantial materials so as to prevent persons from failing into them. Excavations or trenches exceeding 5 ft (1.5 m) should have shoring to walls and faces or as stipulated by regulations. Ladder access must be provided to and from all excavations and trenches.

Table 708-1: Maximum Allowable Slopes

Soil or Rock Type	Maximum Allowable Slopes (H:V)* for Excavations less than 20 Feet Deep***
Stable Rock	Vertical (90°)
Type A**	0.75 : 1 (53°)
Type B	1 : 1 (45°)
Type C	1.5 : 1 (34°)

* Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
** A short-term maximum allowable slope of 1/2H:1V(63°) is allowed in excavations in Type A soil that are 12 feet
(3.67m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67m) in depth shall be 3/4H:1V(53°).
*** Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or
(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or
(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
(v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:
(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or
(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.
(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.
(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
(v) Dry rock that is not stable; or
(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:
(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or
(ii) Granular soils including gravel, sand, and loamy sand; or
(iii) Submerged soil or soil from which water is freely seeping; or
(iv) Submerged rock that is not stable, or
(v) Material in a sloped, layered system where the layers dip into the excavation or slope of four horizontal to one vertical (4H:1V) or steeper.

Additional aspects to be considered for excavation safety:

i. Vibrating Equipment and water increase the chances of cave-ins.

ii. Look out for settlement, cracks, bulges or falling material in excavation which are warning signs.

iii. Location of utility lines must be determined prior to excavation.

iv. Ladder must be provided if depth of excavation is more than 4ft.

v. Chains for lifting objects should be of Grade 80 or better.

vi. Toxic gases and low oxygen levels should be identified particularly near sewers and natural gas lines. Mechanical ventilation system must be available in these types of conditions.

vii. Contaminated soils should be identified by signs such as, oil sheen, standing water, chemical odours, buried drums, dead vegetation etc.

Protective system for Excavation

Any one or more of the following protective systems shall be adopted for excavations at site. Protective systems designed by a professional engineer shall be adopted at site after approval from “the Engineer” of the Project.

a. Protective system is required if depth of excavation is 5ft. Protective system designed by a professional engineer is required in all types of soil if depth is greater than 20ft.

b. Bench or Slope for excavation (Rock – Straight cut, Type-A - 0.75:1, Type-B - 1:1, Type-C - 1.5:1)

c. Trench Box

d. Shoring Structures

e. Driven interlocking sheeting

f. Soldier piles and lagging

g. Screw jacks

h. Hydraulic jacks.

i. Keep all spoils, equipment, material etc. at least 2ft away from the edge of the excavation.

708.2.3 Fall Protection

i. Fall protection is necessary if work surface is at least 6ft high, or in case of scaffold if work platform is at least 10ft high.

   a. Guard Rails (at least 42" high)

   b. Safety Harness and Personal fall arrest system. The anchor point for lanyards must have load carrying capacity of 5,000 lbs per person attached.

   c. Safety Nets

ii. Falls on the same level

   Fall Protection at same level shall be ensured by adopting following measures:

   a. Keep working areas clean and free from debris.

   b. Keep material properly stacked.

   c. Holes must be properly covered (Cover capacity should be 2 times the load)

   d. Hole covers must be properly marked as "Hole".

   e. Covers must be fastened to prevent displacement.

iii. Impalement Hazard

   a. Reinforcement Steel impalement covers on all exposed rebars.

iv. Falling Objects

   a. Wearing of Hard Hat at all times

   b. Installations of Mesh, Toe Boards and screens.

   c. Canopies to protect workers beneath falling objects hazards.

708.2.4 Elevated Work Platforms Protection

Protection for working on Elevated Work Platform shall be as follows:

i. Extension or Straight Ladders

   a. It should extend 3ft above the top access surface.

   b. Base of ladder should be placed at a distance from the wall at least ¼ of height of the point where ladder touches the wall.

   c. Top of the ladder should be tied to the structure.

ii. Step Ladders

   a. Step ladders should be fully opened.

   b. They should never be leaned against a wall.

   c. Never stand on the top platform or the step below it.

iii. Scaffolds

a. Fall protection is necessary if scaffold is at least 10ft high. If work platform are of 18in or less in width, fall protection must be used regardless of height.

b. Scaffold work platform must be planked end to end.

c. Ladder or ramp is required if access surface is at 2ft or more level difference from the scaffold platform.

d. Mobile scaffold wheels must be locked before climbing. Four Outriggers must be installed if platform is at a distance of 14in or more from the work surface.

e. Scaffold platforms must be free from debris or slippery substances.

iv. Personnel Lifts

a. Boom Lift

b. Scissor Lift

- These should only be operated by trained operators and should be checked before each shift.
- Check for overhead clearance and distance from power lines (Min 10ft).
- Outriggers or extendable axles should be deployed.
- Guard Rails in place and gates and chains should be closed.
- Load limit and distribution of load.
- All safety gear required for work
- Slopes should not exceed equipment rating.
- In scissor lift on guard rails are required as fall protection
- In boom lifts, safety harnesses are also required.
- To exit a lift at various heights, only scissor lifts should be used with two lanyards.

v. Stilts

a. All areas must be clean from debris and other tripping hazards.

708.2.5 Safety Monitoring System for Elevated Areas

Safety monitoring systems for elevated work and their use shall comply with the following provisions:

(1) A safety monitoring system shall not be used as a fall protection system for any work other than roofing work on roof slopes of 2 in 12 (vertical to horizontal) or less.

(2) The use of a safety monitoring system alone (i.e., without the warning line system) is not permitted on elevated areas more than 50 feet (15.25 m) in width.

(3) The employer shall designate a competent person to monitor the safety of other employees and the employer shall ensure that the safety monitor complies with the following requirements:

(a) The safety monitor shall be competent to recognize fall hazards;

(b) The safety monitor shall warn the employee when it appears that the employee is unaware of a fall hazard or is acting in an unsafe manner;

(c) The safety monitor shall be on the same walking/working surface and within visual sighting distance of the employee being monitored;

(d) The safety monitor shall be close enough to communicate orally with the employee; and

(e) The safety monitor shall not have other responsibilities which could take the monitor's attention from the monitoring function.

(4) Mechanical equipment shall not be used or stored in areas where safety monitoring systems are being used to monitor employees engaged in elevated operations.

(5) No employee, other than an employee engaged in elevated work shall be allowed in an area where an employee is being protected by a safety monitoring system.

708.2.6 <u>Power Tools and Electrical Equipment</u>

Power saws, grinders and other power tools must have proper guards in place at all times and be protected at all times by an ELCB unit. Cords and hoses must be placed so as not to create a tripping hazard, or be subjected to damage from equipment or materials. In addition following points shall be followed for safety and protection while using power tools and electrical equipment.

i. Manufacturer's instruction should be followed at all times.

ii. Powder actuated tools should only be operated by trained personnel. Following precautions must be observed:

a. Do not load the tool until ready for use.

b. Never load a fastener with finger on the trigger.

c. Do not point the tool at anyone.

d. Do not use the tool in a flammable atmosphere.

e. Do not drive fastener into any chipped area or very hard or brittle material.

f. Do not drive the fastener through thin material such that it will completely pass through the material.

g. Do not leave loaded powder actuated tool unattended.

h. Tool should be stored unloaded.

iii. <u>Power Tools</u>

a. Never carry a tool by the chord.

b. Never pull on the chord.

c. Keep chords away from heat, oil or sharp edges.

d. Disconnect tools when not in use or being maintained or fitted.

e. Keep people at a safe distance.

f. Secure material with clamps or vice to free you both hands to operate the tool.

g. Do not put your finger on the switch while carrying the tool.

h. Maintain tools properly as per manufacturer's instructions.

i. Do not remove any guards from circular saws etc.

iv. Power Considerations

a. All extension cords should be undamaged, all equipment should be earthed, cords should be passed through areas to minimize interference with other works.

b. Electrocution hazards should be identified and safe distance (10ft) should be kept from energized lines. Use double insulated or grounded tool.

A qualified electrician must carry out all repairs to electrical equipment and electrical installations. This includes fuse repair and replacement.

These basic rules shall be followed at site:

- Keep electrical leads off the ground and on stands.
- Do not hang leads from scaffolding.
- The use of double adaptors and 'piggy back' fittings are not permitted on any site.

Earth leakage protection (ELCBs) is required and the relevant electrical authority prior to use should approve all equipment.

Any damaged leads, wiring, equipment or installation must be removed from service -report faults to your foreman immediately.

During inclement weather, covers must be provided for equipment exposed to the elements. If covers cannot be provided then equipment must not be used.

Electrical leads and equipment must be checked in accordance with appropriate regulations and codes of practice. Report this check to your foreman.

c. Laser of power less than 5mV.

- Post warning signs.
- Turn the laser off when not required.
- Do not look directly into the laser.
- Setup laser above head level or below head level of personnel.

708.2.7 Compressed Air

Many site operations, tools and equipment use compressed air for power or cleaning down. Compressed air can also injure or kill. It can blast slivers of wood, steel and concrete into eyes, through skin, and deep into flesh. It can peel skin off in a second. It can burst lungs. It can even enter the blood stream and stop a heart for good. Check airlines and tools before use, fasten all hose connections securely. Compressed air shall not be used to blow dust from clothing or skin; it can be fatal.

708.2.8 Guard Rails

All openings in the ground and all penetrations in floors shall be fitted with guard rails or handrails. Any missing or damaged guard rail shall be reported promptly. Any barrier removed to carry out work shall be replaced before leaving the area.

708.2.9 Chemical and Fiber-based Products

All chemicals and fiber-based substances introduced to site must not be used unless accompanied by a Materials Safety Data Sheet (MSDS). The responsible foreman will ensure that the use of these products will not be harmful to those workers handling them, and that the correct procedures for use and the type of protective equipment (if necessary) should be worn. If it is not possible to safely use any substance or there is a doubt about MSDS information, then the substance or product must not be used until the correct information is available, or an alternative can be found.

708.2.10 Explosive-powered Tools

These tools use an explosive charge to fire fixings into concrete, steel and timber, and, like a firearm; they are potentially lethal.

- Only trained persons are to use explosive-powered tools.
- Always wear safety glasses and hearing protection.
- Signs must be placed in the area of operation of this equipment.
- No tools shall be left in a loaded condition.
- All explosive-powered tools must be inspected and maintained on a regular basis (complying with relevant regulations).
- Lock away when not in use.

708.2.11 Adjustable Props

These are used to support formwork or carry loads, and require a hardened steel pin at the screw adjuster. Anything except the proper pin shall not be used. Ordinary steel will give way at only 1/5 of the load that the proper pin is designed to take.

Unauthorized alterations to adjustable props shall not be done; tampering with them is viewed very seriously.

708.2.12 Erection of Scaffolding

All scaffolds must be erected in compliance with statutory regulations and such scaffold and accessories must conform to regulations.

Damaged planks must not be used and must be removed from site. Kickboards must be secured in place and guardrails installed.

Mobile scaffolds are frequently used and should be erected as per regulations. They must be fitted with wheel locks, which are to be in place whenever persons are working on them. Mobile scaffolds must not be moved whilst persons are on them.

Access by way of an internal ladder is to be provided to all scaffolds and work platforms and must be used as such. Climbing of scaffold standards is not permitted.

Tools and equipment are not to be left on scaffolds.

Allowable spans shall be determined in compliance with the National Design Specification for Wood Construction published by the National Forest Products Association; paragraph 5 of ANSI A10.8-1988 Scaffolding – Safety Requirements published by the American National Standards Institute; or for 2 X 10 inch (nominal) or 2 X 9 inch (rough) solid sawn wood planks, as shown in the following table:

Table 708-2: Maximum Permissible Spans

Maximum intended nominal load (lb/ft^2)	Maximum permissible span using full thickness undressed lumber (ft)	Maximum permissible span using nominal thickness lumber (ft)
25	10	8
50	8	6
75	6	-

Fabricated planks and platforms may be used in lieu of solid sawn wood planks. Maximum spans for such units shall be as recommended by the manufacturer based on the maximum intended load being calculated as follows:

Table 708-3: Maximum Intended Loads

Related load capacity	Intended load
Light-duty	25 pounds per square foot applied uniformly over the entire span area.
Medium-duty	50 pounds per square foot applied uniformly over the entire span area.
Heavy-duty	75 pounds per square foot applied uniformly over the entire span area.
One-person	250 pounds placed at the center of the span (total 250 pounds).
Two-person	250 pounds placed 18 inches to the left and right of the center of the span (total 500 pounds)
Three-person	250 pounds placed at the center of the span and 250 pounds placed 18 inches to the left and right of the center of the span (total 750 pounds).

Minimum size of tube and coupler scaffolding members will be determined as follows:

Table 708-4: Minimum Size of Members

	Light duty	Medium	Heavy duty
Maximum intended Load	25 lbs/ft^2	50 lbs/ft^2	75 lbs/ft^2
Posts, runners and braces	Nominal 2 in. (1.90 inches) OD steel tube or pipe.	Nominal 2 in. (1.90 inches) OD steel tube or pipe.	Nominal 2 in. (1.90 inches) OD steel tube or pipe.
Bearers	Nominal 2 in. (1.90 inches) OD steel tube or pipe and a maximum post spacing of 4 ft. X 10 ft.	Nominal 2 in. (1.90 inches) OD steel tube or pipe and a maximum post spacing of 4 ft. X 7 ft. or Nominal 2 1/2 in. (2.375 inches) OD steel tube or pipe and a maximum post spacing of 6 ft. X 8 ft.*	Nominal 2 ½"in. (2.375 inches) OD steel tube or pipe and a maximum post spacing of 6 ft. X 6 ft.
Maximum runner spacing vertically	6 ft. 6 in	6 ft. 6 in	6 ft. 6 in

* Bearers shall be installed in the direction of the shorter dimension

Note: Longitudinal diagonal bracing shall be installed at an angle of 45^0 (±5)

Table 708-5: Maximum Number of Planked Levels

Number of Working Levels	Maximum number of additional planked levels			Maximum height of scaffold (in feet)
	Light duty	Medium duty	Heavy duty	
1	16	11	6	125
2	11	1	0	125
3	6	0	0	125
4	1	0	0	125

Check List for Safety Inspection of Scaffolding:

1. Sole Plate (Wooden) should be on level compact ground. If surface is hard e.g. concrete then sole plate is not required.

2. Sole Plate should be at least 1,000Sqcm (160 sq in) with no dimension less than 225mm (8.85 in), the thickness should be at least 38 mm (1.5 in).

3. Base Plate should be firmly fixed with Sole Plate. It should also have leveling screws for adjustment of level.

4. All tubes used for Standards, Transoms and Ledgers should be visibly straight and crack free. Tube ends should have straight level cut.

5. Props (Standards) should be vertical. Check with bubble level.

6. Distance between standards (Bay Length) should be correct. Bay length should be maximum 2.7m for inspection work only, 2.1m for general purpose construction work and 1.8m for heavy duty work.

7. Transom and ledgers should be horizontal. Check with bubble level.

8. Main Transoms should be placed at each bay, and Intermediate Transom at middle of the bay if walking plank thickness requires so.

9. Face Bracings should be provided at every fourth bay, in addition to the first and last bay, this means that the gap between the braced bays is three bays.

10. Transverse (Ledger) Bracing should be provided at every alternate bay.

11. Bracing anchoring points should be within 300mm of Standard-Transom-Ledger Node points (Joints).

12. Swivel / Double couplers should be used for all Bracing. Single couplers should not be used.

13. Couplers should be of correct class as per scaffold design. (Class A has design load capacity of 6.1 kN, and Class B has design load capacity of 9.1 kN)

14. All couplers should be fully tight. Each coupler should be checked individually.

15. Ties (Putlogs) should be provided which anchor the scaffolding with the existing structure so that it may not overturn. Putlogs are to be provided for scaffold having a height to width ratio of more than 4:1. First putlog should be provided at 2.4m (8ft) height and subsequent putlogs should be provided at every 6 m (20ft).

16. Access ladder should be tied at both ends with ladder clamps.

17. Access way should be clear of debris and equipment etc.

18. Lift Height should be minimum 2.0 m.

19. Working Platform Planks should be firm and should not have cracks.

20. Plank dimensions and thickness should be appropriate depending upon the Transom spacing. Plank width should be minimum 225mm, thickness should be minimum 38mm for a Transom spacing of 1.2m; higher thickness (50mm or 63mm) of planks may be used for spanning larger Transom spacing.

21. Gaps between planks should be max. 25mm (1”).

22. Planks should be tied to the transom with plank couplers.

23. Planks overhang distance beyond Transom should be 50-150 mm (2" to 6").

24. Height of top Guard Rail should be between 0.9m (38”) to 1.2m (45”). There should be a middle guard rail at 470mm distance below top rail.

25. Guard Rail should be tied to the Standard with double couplers at each joint.

26. Toe boards should be fixed at each platform. Vertical spacing between toe board and walking surface should be max. 6mm (1/4")

708.2.13 Cranes

Only authorized certificated operators will be permitted to operate cranes. Crane Operators and Doggers must work in close terms with each other, each should know what the other is doing, and they need to co-operate, thus avoiding any dangerous situations. Crane Doggers are to direct crane operators only. Riding the load is prohibited.

Cranes shall only be loaded up to a maximum capacity as mentioned in the loading charts provided by the manufacturer, in addition to meeting all other safety precautions pertaining to operating the crane.

Slings, ropes and chains are to be checked on a daily basis, hands kept clear of pinch points and away from slings on loads.

Chains used in cranes for lifting shall be of Grade 80 or better.

Loads must be correctly slung and persons should never stand under loads.

Crane and mobile machinery operators must check clearance of electrical power lines when setting up or operating.

Any defects with cranes, machinery and associated gear must be reported to the foreman in charge.

708.2.14 Fire Protection

A firefighting program is to be followed throughout all phases of the construction and demolition work involved. It must provide for effective firefighting equipment to be available without delay, and designed to effectively meet all fire hazards as they occur.

Firefighting equipment must be conspicuously located and readily accessible at all times, must be periodically inspected, and be maintained in operating condition.

A fire extinguisher, rated not less than 2A, must be provided for each 3,000 square feet of the protected building area, or major fraction thereof. Travel distance from any point of the protected area to the nearest fire extinguisher must not exceed 100 feet. Acceptable substitutes are a 1/2–inch diameter garden-type hose not to exceed 100 feet and capable of discharging a minimum of 5 gallons per minute, or a 55–gallon drums of water with two fire pails.

The employer must establish an alarm system at the worksite so that employees and the local fire department can be alerted for an emergency.

Additional following safety measures shall be adopted at site:

Flammables:

a. Refueling of power equipment should not be done when running or when hot.

b. Refueling should be done in well ventilated areas.

c. Identify evacuation paths and assembly area.

d. Use correct fire extinguisher.

Fire Extinguisher Classes

a. Class A B C fire extinguishers should be provided at all construction sites

- Class-A used for combustible material e.g. wood, cloth etc.
- Class-B used for combustible fluids e.g. Oil, fuel etc.
- Class C used for electrical fires.
- Class D used for reactive metals.

b. Replace all used fire extinguishers.

c. Evacuate if fire is out of control.

Hot Works

a. Get permit for welding, cutting or other spark producing activity if required.

b. Keep fire extinguisher in immediate work area.

708.2.15 Respiratory Protection

i. Respiratory protection program must be implemented when workers are exposed to dust, vapours, gases or other toxins.

ii. Proper respirator should be selected which should meet the requirements of job site.

iii. Following points must be addressed in Respiratory Program.

a. Develop and implement a written respiratory program.

b. Evaluate respiratory hazards in the work place.

c. Select and provide appropriate respirators.

d. Provide workers medical evaluation and respirator fit testing.

e. Provide for maintenance, storage and cleaning of respirators.

f. Provide workers' training.

g. Evaluate and correct workers' use of respirators.

708.2.16 Concrete and Masonry Work

i. No construction load should be placed on concrete structure unless it is approved by a structural engineer.

ii. Plastic concrete should be adequately protected against accidental spill over or fall during transportation at site through pumps, buckets, tremies or buggies.

iii. Vertical reinforcing steel should be covered by impalement covers.

iv. Masonry saws should be guarded by semi-circular guard.

v. Formwork should be designed, fabricated, erected, supported, braced and maintained to be capable of taking all imposed construction loads.

vi. Erected shoring equipment should be inspected prior to, during and after concreting.

vii. Tiered single post shores should be connected by splices and should designed by a Structural Engineer and should be braced in both transverse directions and well as diagonally.

viii. Single post shores should not be adjusted after pouring of concrete.

ix. Formwork should not be removed unless concrete has gained adequate strength.

x. Re-shoring should not be removed unless supported concrete has gained adequate strength.

xi. Limited access zone should be established at the unscaffolded side of masonry work.

xii. All masonry walls over eight feet in height should be braced against overturning until permanent supporting elements are in place.

708.2.17 Requirements for Precast Concrete

i. Precast concrete wall units, structural framing, and tilt-up wall panels shall be adequately supported to prevent overturning and to prevent collapse until permanent connections are completed.

ii. Lifting inserts which are embedded or otherwise attached to tilt-up precast concrete members shall be capable of supporting at least two times the maximum intended load applied or transmitted to them.

iii. Lifting inserts which are embedded or otherwise attached to precast concrete members, other than the tilt-up members, shall be capable of supporting at least four times the maximum intended load applied or transmitted to them.

iv. Lifting hardware shall be capable of supporting at least five times the maximum intended load applied or transmitted to the lifting hardware.

v. No employee shall be permitted under precast concrete members being lifted or tilted into position except those employees required for the erection of those members.

708.3 MEASUREMENT AND PAYMENT

708.3.1 Work under this item will not be measured or paid separately. Payment of this item shall be deemed to be included in other items of work of contract.

SECTION 709 ENVIRONMENTAL PROTECTION DURING CONSTRUCTION

709.1 DESCRIPTION

The work shall consist of installing measures or performing work to control erosion and minimize the production of sediment and other pollutants to water, land and air from construction activities. Environmental Management Standards shall be implemented at the project site as per ISO 14000 standards. All rules & regulations of Pakistan Environmental Protection Agency and guidelines, applicable on the project shall be implemented at site.

709.2 CONSTRUCTION REQUIREMENTS

709.2.1 Chemical Pollution Control

The contractor shall safely dispose of chemical pollutants (such as fuel, drained lubricating or transmission fluids, grease, soaps, concrete mixer wash water, or asphalt, produced as a byproduct of the construction activities) off site. The contractor is responsible for reporting and cleaning up of all accidental spills and leaks.

In the event a piece of equipment develops a leak during the construction work, the leak shall be repaired before work continues. All excess fluids will be cleaned from the machine prior to its return to the work area.

If a leak occurs when equipment is working in or near a water body, the machine shall be immediately moved a safe distance away from the water body.

Storage:

To ensure that fuel and chemical storage is safe, and that any materials that escape do not cause environmental damage following measures shall be implemented.

a. Minimize fuels and chemicals stored onsite.
b. Install bunds and take other precautions to reduce the risk of spills.
c. Implement a contingency plan to handle spills, so that environmental damage is avoided.

709.2.2 Air Pollution Control

The burning of brush or slash and the disposal of other materials shall adhere to state and local regulations.

Fire prevention measures shall be taken to prevent the start or spreading of wildfires that may result from project activities. Firebreaks or guards shall be constructed and maintained.

It shall be ensured that all vehicles and machinery are fitted with appropriate emission control equipment, maintained frequently and serviced to the manufacturers' specifications.

Smoke from internal combustion engines should not be visible for more than ten seconds

709.2.3 Dust Control

Dust control shall consist of applying water or dust palliative or prevent dust nuisance resulting from contractor’s operations, either within or outside the work right-of-way.

Dust control shall be performed by the contractor at any time dust, resulting from the contractor’s operations, becomes a nuisance or visual impediment, or as directed by

the authority. Failure to adequately control dust will cause the authority to direct the contractor to suspend operations.

The application of water for dust control may be performed by the contractor for contractor's convenience. Water shall be applied as per construction water requirements.

All public access or haul roads used by the contractor during construction of the project shall be treated to fully suppress dust. All dust control methods shall ensure safe construction operations at all times. If chemical dust suppressants are applied, the material shall be a commercially available product specifically designed for dust suppression and the application shall follow manufacturer's requirements and recommendations. A copy of the product data sheet and manufacturer's recommended application procedures shall be provided to the technician before the first application.

As a contingency measure, in areas that do not have access to a reticulated water supply, water stored on-site should never be less than 2,000 litres per hectare of disturbed land surface.

Wherever watering is used to suppress dust, ensure it does not create contaminated run-off that will contaminate surface waters.

Following additional measures shall be adopted for dust control on project sites.

a. Prevent the generation of dust in preference to applying dust suppression measures.
b. Ensure in the project schedule that the area of cleared land is minimized during the drier months of the year, when dust generation is at its greatest. Pave and water haul roads. The frequency of watering will be determined by weather conditions and the erodibility of the soil. If additives in the water are used to increase its dust suppression properties, the chemical should have no adverse environmental impact on adjacent water bodies.
c. Water areas other than haul roads, if they are a source of dust.
d. Ensure that smooth surfaces are deep ripped and left rough and cloddy to reduce the wind velocity at the soil surface.
e. Construct wind fences if this is appropriate for the site.

709.2.4 Erosion Control

Erosion and sediment control measures and works shall be installed to prevent or minimize sediment production and transport offsite. The measures and works shall include, but are not limited to, the following:

a. Diversions - Divert water from work areas and collect water from work areas for treatment and safe disposition. Temporary diversions shall be removed and the area restored to its near original condition when the diversions are no longer required or when permanent measures are installed.

b. In-Channel Sediment Control - Sediment produced within the stream channel during construction will be retained in the work area. Sediment retention will be accomplished by using a temporary, excavated sediment trap and/or a barrier constructed of geotextile and hay bales. Turbid water in the retention area may be pumped to a well-vegetated area away from the stream. The vegetation will serve to filter the sediments before the flow returns to the stream. Discharge areas from all pump hoses shall be stabilized. At no time shall the pump discharge be allowed to cause erosion at the discharge point.

c. Mulching - Mulch provides temporary protection of the soil surface from erosion. The method of application is specified on the construction drawings.

d. Sediment Basins - Sediment basins collect, settle, and eliminate sediment from eroding areas from impacting properties and streams below the construction site(s). These basins are temporary and shall be removed and the area restored to its original condition when they are no longer required or when permanent measures are installed.

e. Sediment Filters - Straw bale filters or geotextile sediment fences (silt fence) trap sediment from areas of limited runoff. Sediment filters shall be properly anchored to prevent erosion under or around them. These filters are temporary and shall be removed and the area restored to its original condition when they are no longer required or when permanent measures are installed. The method is shown on the construction drawings.

f. Seeding - Seeding to protect disturbed areas shall occur as soon as reasonably possible following completion of that earthwork activity. All seeding operations shall be performed in such a manner that the seeds are applied in the specified quantities uniformly in the designated areas. The method and rate of seed application are specified on the construction drawings.

g. Silt Curtain or Turbidity Barrier - Silt Curtain and Turbidity Barriers can be used to minimize the transport of sediment from an area where construction activities are occurring within or directly adjacent to a waterway or water body. The fabric shall be removed after the construction activities have ceased and the sediment has settled. Care should be taken to prevent the re-suspension of sediment during removal.

h. Staging of Earthwork Activities - The excavation and moving of soil materials shall be staged to minimize the area disturbed and the time these locations are vulnerable to erosion.

i. Stockpiling Material - The stockpiled materials shall be protected from concentrated flows and/or flooding, to minimize sediment movement offsite.

j. Stream Crossings - Culverts or bridges should be used where equipment crosses streams. They are temporary and shall be removed and the area restored to its near original condition when the crossings are no longer required or when permanent measures are installed.

k. Waterways - Waterways shall be used to safely dispose off runoff from fields, diversions, and other structures or measures. These works are temporary and shall be removed and the area restored to its original condition when they are no longer required or when permanent measures are installed.

l. It is the responsibility of the contractor for the cleanup or removal of sediment transported offsite due to failure to maintain erosion control measures during all phases of the construction.

m. Program construction activities so that the area of exposed soil is minimised during times of the year when the potential for erosion is high, for example during summer when intense rainstorms are common

n. Stabilise the site and install and maintain erosion controls so that they remain effective during any pause in construction. This is particularly important if a project stops during the wetter months.

o. Keep vehicles to well-defined haul roads.

p. Keep haul roads off sloping terrain wherever practical.

q. Designed the slope of a cut to minimize the angle of incline.

r. Installation of rock structures on the site to retard water flows is an effective measure to reduce erosion in areas where high water flows are expected

s. Any natural drainage lines that discharge water on to the top of a slope should be directed to grassed areas by intercept drains. Otherwise water will run down the slope, eroding it. Perimeter banks or sediment fences should also be constructed at the toe of the slope to contain sediment run-off.

709.2.5 Dewatering of Site

To ensure that de-watering operations do not result in turbid water entering natural waterways following measures shall be adopted.

a. Treat contaminated water pumped into the stormwater system or a natural waterway to remove sediment if the turbidity exceeds 30 NTU (nephelometric turbidity units).

b. Ensure that the level of suspended solids in waters pumped into natural waterways never exceeds the regulatory water quality standard.

c. De-water by pumping water, wherever practical, on to vegetated area of sufficient width to remove suspended soil, or to sediment control devices.

d. Supervise all pumping and implement precautions to ensure that turbidity of pumped water is minimized.

e. Monitor every hour during a pumping operation the turbidity of water pumped directly to a natural waterway or a drainage system discharging to a natural waterway.

709.2.6 Management of Stockpiles

To manage soil stockpiles so that dust and sediment in run-off are minimized following measures shall be adopted.

a. Minimize the number of stockpiles, and the area and the time stockpiles are exposed.

b. Keep topsoil and underburden stockpiles separate.

c. Locate stockpiles away from drainage lines, at least 10 meters away from natural waterways and where they will be least susceptible to wind erosion.

d. Ensure that stockpiles and batters are designed with slopes no greater than 2:1 (horizontal/vertical).

e. Stabilize stockpiles and batters that will remain bare for more than 28 days by covering with mulch or anchored fabrics or seeding with sterile grass.

f. Establish sediment controls around unsterilized stockpiles and batters.

g. Suppress dust on stockpiles and batters, as circumstances demand.

709.2.7 Noise Pollution and Vibration

a. Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site.

b. Enclose noisy equipment.

c. Provide noise attenuation screens, where appropriate.

d. Where an activity is likely to cause a noise nuisance to nearby residents, restrict operating hours to between 7 am and 6 pm weekdays and 7 am to 1 pm Saturday, except where, for practical reasons, the activity is unavoidable.

e. Noise should not be above background levels inside any adjacent residence between 10 pm and 7 am.

f. Advise local residents when unavoidable out-of-hours work will occur.

g. Schedule deliveries to the site so that disruption to local amenity and traffic are minimized.

h. Conduct a study on the impact of ground vibration from construction activities, where these operations occur within 50 meters of a building and take appropriate action.

i. Minimize air vibrations, particularly from blasting.

709.2.8 Waste Minimization

To minimize the waste load discharged to the environment following measures shall be adopted.

a. Carry out a waste minimization assessment which examines opportunities for waste avoidance reduction, reuse and recycling.

b. Reduce wastes by selecting, in order of preference, avoidance, reduction, reuse and recycling.

c. Incorporate waste minimization targets and measures into the environmental management plan.

709.2.9 Litter

To ensure that all litter is disposed of in a responsible manner, and is not released into the environment following measures shall be adopted.

a. Maintain a high quality of housekeeping and ensure that materials are not left where they can be washed or blown away to become litter.

b. Provide bins for construction workers and staff at locations where they consume food.

c. Conduct ongoing awareness with staff of the need to avoid littering.

709.2.10 Keeping Roads Clean and Protecting Existing Infrastructure

To ensure that roads are kept clean of soil and existing infrastructure is protected, following measures shall be adopted.

a. Install wheel washes and rumble grids at all main road crossings.

b. Ensure that the roads are swept at least once a day on uncontrolled road crossings when construction vehicles are travelling off the site.

c. Install litter traps lined with filter cloth in all side-entry pits.

d. Cover all loads of soil being taken off site for disposal.

e. In built-up areas, care needs to be taken in working near existing infrastructure services such as drainage and sewerage pipes. It is important to ensure that any existing drainage or sewerage pipes that intersect the construction site or are adjacent to it are not overstressed or damaged by movement or placement of construction plant or materials, or construction activities.

709.2.11 Maintenance, Removal and Restoration

All pollution control measures and temporary works shall be adequately maintained in a functional condition for the duration of the construction period. All temporary measures shall be removed and the site restored to near original condition.

All equipment used within the construction site shall be well maintained. All equipment lines and fittings shall be checked on a daily basis to ensure that they are in good working order.

709.2.12 Inspections, Monitoring and Auditing

Inspection, Monitoring and Auditing of Environmental Measures implemented at project site shall be carried out on regular basis to ensure compliance throughout the tenure of the project.

The frequency of inspections depends on the risks posed to the environment by each construction activity or the nature of the site.

Regular monitoring of air and water and taking of noise measurements is required to determine whether standards, established by the Environmental Management Plan, are being complied with. This should commence before construction to provide a baseline against which data collected during construction can be compared.

Independent audits may be conducted on environmental performance and systems by experts in construction activities and environmental management. Different people can be used for each type of audit.

709.3 MEASUREMENT AND PAYMENT

709.3.1 Work under this item will not be measured or paid separately. Payment of this item shall be deemed to be included in other items of work of contract.

RECOMMENDED
MAJOR
CONSTRUCTION EQUIPMENT

RECOMMENDED MAJOR CONSTRUCTION EQUIPMENT

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION /MEDIUM SIZE PROJECTS.	MAINTENANCE PROJECTS.
101	Clearing and Grubbing.	1 Bulldozer (160 H. P) or Grader (140 H. P) 2 Dumper (10 T)	--	--
102	Removal of Trees	1 Excavator (0.3 CM)	--	--
103	Stripping.	1 Grader (140 H. P.)	--	--
104	Compaction of Natural Ground.	1 Static Tandem Roller (8-12 T) 2 Water Tanker (Tow Type)	-- --	-- --
105	Roadway Excavation.	1 Bull Dozer (160-200 H.P.) 2 Front End Loader (2-3 CM) 3 Dump Truck (10-18T)	1 Bull Dozer (160 H.P.) 2 Tractor/Trolley (50 H.P.)	
107	Structural Excavation and Backfill	1 Excavator (0.3 CM) 2 Plate Compactor	Plate Compactor	Plate Compactor.
108	Formation of Embankment.	1 Grader (140-165 HP) 2 Combination / sheep-foot or pneumatic Roller (8-12T) 3 Water Tanker (Bowser Type)	Grader (140 HP) Combination / sheepfoot or pneumatic Roller (8-12T) Water Tanker (Bowser Type)	1 Heavy Duty Tractor with Blade (80 H.P.) 2 Static Roller (8-12T) 3 Water Tanker (Tow-Type).
109, 110, 111 & 112	Sub-grade Preparation.	1 Grader (140-165 HP) with scarifier. 2 Water Tanker (Tow-Type) 3 Combination Roller (10-12T)	--	--
113	Bitumen Stabilized Sub-grade.	1 Grader (140-165 HP) with scarifier. 2 Asphalt Distributor. 3 Tandem Roller (10-12T)	--	--

RECOMMENDED MAJOR CONSTRUCTION EQUIPMENT

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION /MEDIUM SIZE PROJECTS.	MAINTENANCE PROJECTS.
114	Dressing and Compaction of Berms.	--	1 Tractor with Blade (50-80 HP) 2 Water Tanker (Tow Type) 3 Static Roller (10-12T)	1 Tractor with Blade (50 H.P.) 2 Water Tanker (Tow Type) 3 Static Roller (10-12T)
201	Granular Sub-Base.	1 Power Broom /Air Compressor 2 Grader With Scarifier (140 H.P.) 3 Water Bowser. 4 Combination Roller (10-12T)	1 Heavy Duty Tractor with Blade. 2 Water Tanker (Tow type) 3 Static Roller (10-12T)	1 Tractor / Trolley with Blade (50 H.P.) 2 Water tanker (Tow Type) 3 Static Roller (10-12T)
202 & 211	Base Course	1 Power Broom / Air compressor. 2 Front End Loader (2-3 CM) 3 Pugmill (50-100T/ Hour) 4 Dumper (10-15T) 5 Base Paver (4M wide) 6 Combination roller (10-12T)	1 Grader (140 H.P.) with Articulated Blade. 2 Water Tanker (Tow type) 3 Combination Roller (10-12T)	1 Heavy Duty Tractor / Trolley with Blade (80 H.P.) 2 Water Tanker (Tow Type) 3 Static Roller (10-12T)
204	Soil Cement Stabilized Sub-base / base.	1 Concrete Batching and forced mixing plant (30 CM/Hour). 2 Dumper (10-15T) 3 Base Paver (4M wide) 4 Tandem Roller (10-12T)	Same Equipment as for major project.	--
212	Bitumen Stabilized i) Sub-base. Bitumen Stabilized ii) Base. (a) Cold Mix (b) Hot Mix	1 Grader with scarifier (140 H.P.) 2 Asphalt Distributor 3 Combination roller (10-12T) 1 Grader with Scarifier (140-165 H.P.) 2 Bitumen Distributor (Auto/Tow Type) 3 Tandem Static Roller (10-12T) Equipment mentioned as per Item 203.	1 Heavy Duty Tractor with Blade. 2 Combination Roller (10-12T) Same Equip-ment as for major projects. Equipment mentioned as per Item 203.	--

RECOMMENDED MAJOR CONSTRUCTION EQUIPMENT

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION/MEDIUM SIZE PROJECTS.	MAINTENANCE PROJECTS.
213	Recycling of Road Pavement Structure / Soil Stabilization.	--	1 Cold Mix Recycler. 2 Grader (140 HP) Water Tanker 3 (Tow Type) Vib. Combination 4 Roller (10-12T)	--
203 305 314	Asphaltic Base Course / Wearing Course Plant Mix.	1 Power Broom / Air-Compressor. 2 Front End Loader (2-3 CM) 3 Asphalt Plant (80-120T) 4 Paver (4 M wide) 5 Dumper (10-18T) 6 P.T.R (9 Wheeler 21 T) 7 Tandem Vibratory Roller (10-12T)	1 Front End loader (1.50-2.50 CM) Asphalt Plant (20- 2 40T) Dumper (10T) 3 Paver 4 (4M wide) P.T.R. 5 (9 Wheeled)18-T. Tandem Vibratory Roller. (8-10T) 6	1 Bitumen Aggregate Mixer (1 CM) 2 Wheel Barrow (0.5 CM) 3 Tandem Vibratory Roller (8-10T) 4 Tractor / Trolley (50 H.P.)
308	Re-cycling of Asphalt Concrete	--	1 Recycling Machine. 2 Bitumen Bowser plus all equipment for Asphaltic Concrete under Item 305	--
115 & 306	Shoulder Treatment.	1 Grader (140 H.P.) 2 Dumpers (10T) 3 Water Tanker (Tow type) 4 Combination Roller (10-12T)	1 Heavy Duty Tractor / Trolley with Blade. 2 Water Tanker (Two type) 3 Static Roller (10-12T)	1 Tractor / Trolley with Blade (50 H.P.) 2 Water Tanker (Tow type) 3 Static Roller (8-10T)
309	Cold Milling	--	1 Cold Milling Machine (1 M wide) 2 Dumpers (10T) 3 Water Tanker (Tow type)	1 Cold Milling Machine (1 M wide) 2 Dumpers (10T) Water Tanker 3 (Tow type)
302 & 303	Bituminous Prime Coat / Tack Coat.	1 Power Broom / Air-Compressor. 2 Engine Operated Bitumen pressure distributor (Auto-Type)	1 Manual Operated Bitumen pressure distributor (Tow Type)	Manually Operated Bitumen pressure distributor (Tow Type)

RECOMMENDED MAJOR CONSTRUCTION EQUIPMENT

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION /MEDIUM SIZE PROJECTS.	MAINTENANCE PROJECTS.
304 & 313	Bituminous Surface Treatment.	1 Power Broom/Air-Compressor. 2 Aggregate Spreader. 3 Engine Operated Bitumen pressure distributor (Auto-Type) 4 Dump Truck (10T) 5 Rubber Mounted Tandem Roller or P.T.R (9 Wheeled-18T)	1 Aggregate Spreader (3-4 M wide) 2 Bitumen Distributor Auto or Tow-Type. 3 Dump Truck (10T). 4 Static Tandem Roller (8-10T)	1 Tractor/Trolley (50 H.P.) 2 Bitumen Sprayer (manual) static Tandem Roller (18T)
310	Concrete Pavements.	Concrete Batching Plant (30 CM/H). Concrete Paving Machine (4 M wide) Front End Loader (2-3 CM) Concrete Transit mixer (6 CM)	--	--
401	Concrete	1 Concrete Batching Plant (30 CM/H) 2 Front End Loader (2-3 CM) 3 Concrete Transit Mixer (6 CM) 4 Crane (20-45T). 5 Vibrator (40mm-50mm) 6 Concrete Finisher.	1 Concrete Static Mixer (1 CM) 2 Tractor Trolley (50 H.P.) 3 Crane (20T) 4 Water Tanker (Tow Type) 5 Vibrator (40mm-50mm)	1 Concrete Static Mixer (1/2-1 CM) 2 Tractor/Trolley (50 H.P.) 3 Vibrator. 4 Wheel Borrows.
405	Prestressed Concrete Structures	1 Prestressing Equipment plus all equipment contained in Item No. 401. 2 Heavy Duty Crane or Beam launching Truss.	--	--
407	Piling.	Piling Equipment plus all those equipment mentioned in Item 401, for major projects.	--	--
608	Pavement Marking	Road Marking Machine	Manual	Manual

LIST OF APPROVED MANUFACTURERS / SUPPLIERS/SOURCES – HIGHWAY AND BRIDGE WORKS

This list of recommended manufactures / Suppliers of different materials / equipments with brand names have been provided in order to establish a standard level of performance. The Contractor is supposed to provide and fix the materials / equipments of acceptable quality from the list or equivalent as approved by the Engineer. Material from approved list shall stand rejected, if it fails in any of the specified tests or quality standards.

Sr. No.	Description	Manufacturer/Supplier/Source
1	Cement (OPC, SR)	Lucky, Pioneer, Maple Leaf, State Cement, Fouji, Askari, Facto, Charat, DG Khan
2	Concrete Admixture & Sealants	Sika, Fosroc, BASF, Ultra, Fastchem, Vertex, MAPEI, KALON, Mitchell
3	Anchoring / Fixing Systems	Strong hold, Strong force, Hilti, Fischer
4	Sand (for RCC)	From approved source (AJK) as per Mix Design and for high risk structure/construction Lawrencepur.
5	Sand (other works)	From approved source (AJK) as per nature of work
6	Aggregate	From approved source (AJK) looking to the nature of work as per recommendations of M/s NESPAK under study of Construction material sources in and around AJ&K.
7	Steel Reinforcement	AFCO, Ittefaq, Fazal, Razzak, Pak Steel, Model Steel, FF Steel, Nizami Brothers, Moiz Steel, Tayyaba Steel, Poineer
8	Prestressing Steel & Wires / Ropes	Wire Manufacturing Industries, Post Tension Services, United Wire.
9	Fence, Razor and Barbed Wire	Pakistan Wire Industries, Nizami Brothers
10	Bitumen	National Refinery, Attock Petroleum, PARCO
11	Bricks/Blocks	Local (Brand / source to be approved by the Engineer)
12	Cat Eyes / Road Stud Reflectors/ Dividers	3M Enterprise, Ikan Engineering, Long Man, BERGER
13	Expansion Joints/ Bearing Pads	Rainbow Rubber Industries, Long Man, Freyssinet BERGER

14	RCC Pipes	Shalimar, Pakistan Pipes, National Pipe Industry
15	Concrete Pavers	Tuff Tiles, Izhar, Envicrete, National Pavers, Banu Mukhtar

Conditions of Enlistment

1. The subject list is provisional, which may be changed and refreshed when deemed necessary.
2. Addition or Subtraction of any company, manufacturer, supplier and vender depends on its performance.
3. The client is responsible to ensure quality, by batch wise testing, from well reputed material testing laboratory.

REFERENCES

The following references were taken into account for the compilation of General Specifications for Highways developed for Planning and Development Department, Government of Azad Jammu and Kashmir.

i. **General Specifications National Highway Authority, Government of Pakistan.**

ii. **AASHTO / ASTM Specifications (USA)**

iii. **British Standard Specifications (BS)**

iv. **Eurocode**

v. **SHRP Publications (USA)**

vi. **ACI Manual of Concrete Practice**

vii. **AISC Manual of Steel Construction**

viii. **The Asphalt Institute Manual Series**

ix. **Equipment Catalogues of different manufacturers**

x. **Various other international publications**

PATRONAGE (Client)

Client's Senior Executives, whose patronage contributed towards successful accomplishment of the assignment.

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