

TABLE OF CONTENTS

5.	PLAIN AND REINFORCED CONCRETE	5-1
5.1	SCOPE	5-1
5.2	DRY RAMMING OF BRICK OR STONE BALLAST	5-1
5.2.1	BRICK BALLAST	5-1
5.2.2	PLACING & RAMMING OF BRICK BAT	5-1
5.3	PLAIN & REINFORCED CEMENT CONCRETE	5-1
5.3.1	MATERIALS	5-1
5.3.1.1	CEMENT	5-1
5.3.1.2	AGGREGATES	5-3
5.3.1.3	FINE AGGREGATE (Sand)	5-3
5.3.1.4	SAND FOR MORTAR	5-4
5.3.1.5	COARSE AGGREGATES (Aggregates)	5-5
5.3.1.6	WATER	5-7
5.3.1.7	ADMIXTURES	5-7
5.3.1.8	WATER-STOPS	5-7
5.3.1.9	JOINT SEALING COMPOUND	5-8
5.3.1.10	EXPANSION JOINT FILLER	5-8
5.3.1.11	NON-SHRINK GROUT	5-8
5.3.2	PROPORTIONING & MIXING OF CONCRETE MIX	5-9
5.3.2.1	PROPORTIONING OF INGREDIENTS	5-9
5.3.2.2	MINIMUM CUBE STRENGTH REQUIREMENT	5-9
5.3.2.3	MIXING	5-10
5.3.2.4	HAND MIXING	5-10
5.3.2.5	MACHINE MIXING	5-11
5.3.3	CONVEYING	5-13
5.3.4	PLACING	5-13
5.3.5	EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS	5-16
5.3.6	INSTALLATION OF WATER STOPS	5-18
5.3.7	CURING	5-18

5.3.8	REPAIR OF CONCRETE	5-19
5.3.9	FINISHES AND FINISHING	5-20
5.4	CONCRETE REINFORCEMENT	5-22
5.4.1	GENERAL	5-22
5.4.2	RELATED WORKS	5-22
5.4.3	SUBMITTALS	5-22
5.4.4	TOLERANCES	5-22
5.4.5	DELIVERY AND STORAGE	5-22
5.4.6	MATERIALS	5-23
5.4.7	EXECUTION	5-23
5.5	CONCRETE FORM WORK	5-24
5.5.1	GENERAL	5-24
5.5.2	RELATED WORK	5-24
5.5.3	SUBMITTALS	5-25
5.5.4	FORM MATERIALS	5-25
5.5.5	INSTALLATION	5-25
5.5.6	REMOVAL OF FORMS	5-26
5.5.7	COORDINATION	5-26
5.5.8	RE-USE OF FORMS	5-26
5.6	PRECAST CEMENT CONCRETE	5-27
5.6.1	GENERAL	5-27
5.6.2	PRECASTING FLOOR	5-27
5.6.3	MOULDS	5-27
5.6.4	DESIGN OF MOULDS AND LIFTING APPARATUS TO BE APPROVED	5-27
5.6.5	SETTING UP MOULDS	5-27
5.6.6	DEPOSITING CONCRETE IN MOULDS	5-27
5.6.7	REMOVAL OF MOULDS	5-28
5.6.8	PRECAST CONCRETE NOT SQUARE OR HONEY COMBED.	5-28
5.6.9	BROKEN OR DAMAGED PRECAST CONCRETE	5-28
5.6.10	LIFTING AND DATING PRECAST CONCRETE.	5-28
5.6.11	STACKING PRECAST CONCRETE.	5-28

5.6.12	DATE OF USING	5-28
5.6.13	OTHER RESPECT	5-28
5.7	FOAM CONCRETE	5-28
5.8	MEASUREMENT & PAYMENT	5-29
5.8.1	GENERAL	5-29
5.8.2	COMPOSITE RATE	5-29
5.8.3	LABOUR RATE	5-29
5.8.4	QUANTIFICATION	5-29

5. PLAIN AND REINFORCED CONCRETE

5.1 SCOPE

The work shall include furnishing of all labour, materials, plant, equipment, accessories and services as required to complete the concrete items as shown on the drawings, specified herein and/or as directed by the Engineer-in-Charge. The materials herein specified shall be proportioned, mixed, formed and placed in accordance with the herein stated requirements. The stipulations and requirements herein set forth shall apply except when such stipulations and requirements are specifically modified by the Engineer-in-Charge for any particular item of work.

The Contractor shall submit method statement before starting of concreting operations. The method statement shall provide the procedures and resources planned to be employed for completion of construction and maintenance of work as specified.

5.2 DRY RAMMING OF BRICK OR STONE BALLAST

5.2.1 BRICK BALLAST

The brick ballast, wherever specified for use in concrete shall be obtained by breaking bats of 1st class well burnt bricks to the specified sizes usually 1½ inches to 2 inches (40mm to 50mm). They shall be screened through the appropriate sieves to remove dust and under size ballast.

5.2.2 PLACING & RAMMING OF BRICK BAT

Wherever brick bats is specified for placement in foundations to provide a firm base, the ballast from pre-approved stacks shall be placed evenly in layers, not exceeding 6 inches (15 cm) thickness in the foundation trench and thoroughly consolidated by means of small plate compactor (may be hand operated) or square rammer. If required/directed by the Engineer-in-Charge small quantity of water may be sprinkled on the brick ballast by means of can fitted with rose. The quantity of water will be just enough to facilitate the consolidation and it should not make the foundation muddy.

5.3 PLAIN & REINFORCED CEMENT CONCRETE

5.3.1 MATERIALS

5.3.1.1 CEMENT

a) General

Cement shall be fresh, furnished in sacks or in bulk form as approved by the Engineer-in-Charge. Unless otherwise permitted, cement from not more than two plants shall be used and in general, the product of only one plant shall be used in any particular section of the work. Cement recovered through cleaning of sacks shall not be used.

b) Portland Cement

Portland cement shall be of Pakistan origin and manufacture unless otherwise approved by the Engineer-in-Charge. Portland cement shall conform to Pakistan Standard 232 or to British Standard 12 or to ASTM C 150 type 1. Portland cement conforming to ASTM C 150, Rapid hardening type III or Sulphate Resistant, Type-V or conforming to BS4027 or ASTM C-150 may also be used in certain parts of the Works as specified or directed by the

Engineer-in-Charge. Where specified Low Heat Cement complying with BS 1370 shall be used.

The Contractor shall use Pozzolanic materials (blast-furnace slag or fly ash or calcined clay) by blending the materials with Ordinary Portland Cement/Sulphate Resisting Cement (whichever is specified in the Contract when alkaline reactive aggregates are used) by replacing up to maximum of 40% of cement. The slag cement thus formed shall conform to BS 146 or ASTM C 595. Raw or Calcined natural pozzolan shall conform to ASTM C618 Class N or Class F. The granulated iron blast-furnace slag shall be finely ground and shall conform to ASTM C989 Grade 80, 100 or 120. The final proportions of OPC/SRC and Pozzolanic materials shall be determined by the Contractor and approved by the Engineer-in-Charge before each mix. The mix will normally be designed by the Contractor to have:

- i) A mortar bar reduction not less than 75% at 14 days when tested in accordance with ASTM C441, and
- ii) A heat of hydration of less than 70 calories per gram of Pozzolanic materials (blast-furnace slag or fly ash or calcined clay) at 7 days when tested in accordance with ASTM C186.

c) Transportation of Cement

Transportation of the cement from the factory to the Site stores and to the point of use shall be accomplished in such a manner that the cement is completely protected from exposure to moisture. Cement which has been adversely affected by moisture, as determined by the Engineer-in-Charge, shall be rejected. Cement in sacks shall be delivered in strong, well-made sacks, each plainly marked with the manufacturer's name, brand, type of cement and the weight of cement contained therein. Packages varying from the standard weight marked thereon may be rejected and if the average weight of packages in any consignment as shown by weighing fifty packages taken at random, is less than that marked on the packages, the entire consignment may be rejected. Packages received in broken or damaged condition shall be rejected or may be accepted only as fractional packages as determined by the Engineer-in-Charge.

d) Storage of Cement

Cement shall be stored at Site in dry, weather tight and properly ventilated stores. All storage facilities shall be subject to approval and shall be such as to permit easy access for inspection and identification of each consignment. Adequate storage capacity shall be furnished to provide sufficient cement to meet the peak needs of the project. The following special precautions shall be observed for storage of cement:

1. Reduce the time of storage as much as possible.
2. The sack should be stacked closely on damp proof or timber raised a foot or so from the ground with the air space below.
3. To avoid bursting of bags and setting under pressure the height of stack should be limited to eight(8) bags.

The best method of storage is that adopted by the cement manufacturers viz; in bulk; and bins of loose cement 6' (six feet) or more in depth can be intact for longer than one year.

The Contractor shall use cement in the approximate chronological order in which it is received at the Site.

Cement storage facilities shall be emptied and cleaned by the Contractor when so directed. However, the interval between required cleaning normally will not be less than four months.

Suitable, accurate scales shall be provided by the Contractor to weigh the cement in stores and elsewhere on the Site, if required, and he shall also furnish all necessary test weights.

5.3.1.2 AGGREGATES

a) Requirements

The nominal maximum size of the aggregates shall not be larger than one fifth of the narrowest dimension of the finished wall or slab, or larger than three fourth of the minimum clear spacing between the reinforcing steel and embedment. These limitations may be waived if, in the judgement of the Engineer-in-Charge, workability and method of consolidation be such that the concrete can be placed without honey-combs or voids.

Aggregate shall be stored at the Site in such a manner as to prevent its contamination with dust or other material. Aggregate which has deteriorated or which has been contaminated shall not be used for concrete. All methods employed by the Contractor for loading, unloading, handling and stockpiling aggregates shall be subject to the approval of the Engineer-in-Charge. Sufficient quantities of aggregate shall be maintained at the Site at all times to assure continuous placement and completion of any lift of concrete started.

b) Composition

The use of natural sand or a combination of natural and manufactured sand may be permitted, provided that the fine aggregate meets the applicable requirements of the Specifications for the particular use intended. Coarse aggregate shall consist of gravel, crushed stone or a combination thereof.

The aggregates shall be non-alkaline reactive in accordance with the provisions of ASTM C-227, C-289.

c) Source

The Contractor shall obtain concrete aggregate from deposits of natural sand and gravel or shall procure crushed aggregate from approved quarries (refer to construction material source study) which produce aggregates meeting with the Specifications contained herein.

d) Processed Aggregates

The Contractor in procuring the processed aggregates or in planning his aggregate processing operations shall ensure that the aggregates, as delivered to the mixer, consist of clean, hard and uncoated particles; light weight elements (chalk, clay, coal) are separated by segregation under water by vibration where required and the fines are removed from the coarse aggregate by adequate washing. The coarse aggregate shall be re-screened just prior to delivery to the concrete mixer bins. The moisture content of coarse and fine aggregates shall be as directed by the Engineer-in-Charge. Compliance with the aggregate grading and uniformity requirements shall be determined before the material is delivered at the mixer. All aggregates shall be sieved and washed with clean water. The aggregates shall conform to the specific requirements given hereinafter.

5.3.1.3 FINE AGGREGATE (SAND)

1. General

The term sand is used to designate aggregates in which the maximum size of particles is 3/16 of an inch (4.76 mm) according to BS-882).

2. Quality

- i) The sand particles of finished sand shall be hard, dense, durable, unquoted inorganic rock fragments fire resistant and all sand shall be washed free from injurious amounts of clay lumps, soft or flaky particles, shale, alkali, organic matter, loam, mica and other deleterious

substances. The maximum percentage of individual deleterious substances in the sand shall not exceed the following values:

Description	Percent by weight
passing No. 200 screen(ASTM Designation: C117)	3
Lightweight material(ASTM Designation: C142)	2
Clay lumps(ASTM Designation: C143)	1
Total of other deleterious substances (Such as Alkali, Mica Coated Grains, Soft Flaky Particles & Loam	2

- ii) The sum of the percentages of all deleterious substances shall not exceed five percent, by weight. Sand producing a colour darker than the standard in the colorimetric test for organic impurities (ASTM Designation: C-40) may be rejected. When required by the Engineer-in-Charge, the sand shall be subjected to a soundness test and may be rejected if the portion retained on a No. 50 screen when subjected to five cycles of the sodium-sulphate test for soundness (ASTM Designation : C-88) shows a weighted average loss of more than 8% by weight.

3. Grading

The grading of fine aggregate as delivered to the mixers shall conform to the requirements given in Table 5.3(a).

Table 5.3(a)
Grading of Fine Aggregates

Sieve size Standard square mesh	Percentage passing (by weight)
9.50 mm (3/8 inch)	100
4.75 mm (No. 4)	95 to 100
2.36 mm (No. 8)	80 to 100
1.18 mm (No. 16)	50 to 85
600.00 um (No. 30)	25 to 60
300.00 um (No. 50)	10 to 30
150.00 um (No.100)	2 to 10

The Fineness Modulus shall range between 2.31 and 2.51.

5.3.1.4 SAND FOR MORTAR

All sand for mortar used in the construction of brick paving, brick lining and brick masonry shall be natural sand and when tested by means of standard screens (ASTM Designation : E11) shall conform to the following limits:

Screen No.	Percentage by weight, passing screen
8	100
100	15 (Maximum)

Within the above range, the sand shall be well-graded and as coarse as practicable for the production of workable mortar.

5.3.1.5 COARSE AGGREGATES (AGGREGATES)

1. General

The term “Aggregates” is used to designate aggregates which are reasonably well graded between 3/16 to 4 inches.

2. Quality

- a) The aggregate shall consist of well-shaped, hard, dense, durable unquoted rock fragments and all aggregates shall be free from injurious amounts of deleterious substances adherent coatings and fire resistant. The percentages of individual deleterious substances in any size aggregates shall not exceed the following values:-

Description	Percent, by weight
Material passing No. 200 screen(ASTM Designation: C117)	1
Lightweight material(ASTM Designation: C123)	2
Clay lumps(ASTM Designation: C142)	1/2
Other deleterious substances	1

- b) The sum of the percentages of all deleterious substances in any size shall not exceed three percent, by weight. Aggregates may be rejected if they fail to meet the following test requirements:-
- i) Los Angeles rattler test (ASTM Designation : C131). If the loss exceeds ten percent by weight, at 100 revolutions, or 40 percent by weight at 500 revolutions.
- ii) Sodium sulphate test for soundness (ASTM Designation : C88). If the weighted average loss after five cycles is more than ten percent by weight.
- iii) Specific gravity (ASTM Designation : C 127). If the specific gravity (saturated surface – dry basis) is less than 2.60.

3. Grading

The grading of fine aggregate as delivered to the mixers shall conform to the requirements given in Table 5.3(b).

4. Particle Shape

The particles of coarse aggregate shall be well shaped and the quantity of flat and elongated particles in the separated size groups of coarse aggregate, as defined and determined according to BS 812, shall not exceed 15 per cent by weight in any size group. A flat particle is one having a ratio of width to thickness greater than three. An elongated particle is one having a ratio of length to width greater than three.

5. Soft Particles

The Contractor in procuring processed aggregates shall make whatever provisions are necessary, as regards methods and equipment, to ensure effective elimination of soft particles from all aggregates to the degree that the percentage of soft particles present in the processed coarse aggregate does not exceed 3 per cent by weight when determined in accordance with the applicable requirements of ASTM C 851.

6 Tests & Approval

- a) All aggregates shall be subject to testing by the Engineer-in-Charge in accordance with the designated test methods to determine whether the aggregates meet the requirements of these Specifications. Aggregates not meeting the requirements of these Specifications as determined by tests or inspection may be rejected.

TABLE 5.3(b)
Grading Requirements for Coarse Aggregate (ASTM C-33-03)

Sr. No.	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square openings) Weight Percentage												
		4"	3½"	3"	2½"	2"	1½"	1"	¾"	½"	3/8"	No.4	No.8	No.100
1.	3½" to 1½"	100	90 to 100	—	25 to 60	—	0 to 15	—	0 to 5	—	—	—	—	—
2.	2½" to 1½"	—	—	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—	—	—	—
3.	2" to 1"	—	—	—	100	90 to 100	35 to 70	0 to 15	—	0 to 5	—	—	—	—
4.	2" to No. 4	—	—	—	100	95 to 100	—	35 to 70	—	10 to 30	—	0 to 5	—	—
5.	1½" to ¾"	—	—	—	—	100	90 to 100	20 to 55	0 to 15	—	0 to 5	—	—	—
6.	1½" to ¾"	—	—	—	—	100	95 to 100	—	35 to 70	—	10 to 30	0 to 5	—	—
7.	1" to ½"	—	—	—	—	—	100	90 to 100	20 to 55	0 to 10	0 to 5	—	—	—
8.	1" to ¾"	—	—	—	—	—	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	—	—
9.	1" to No.4	—	—	—	—	—	100	95 to 100	—	25 to 60	—	0 to 10	0 to 5	—
10.	¾" to ⅝"	—	—	—	—	—	—	100	90 to 100	20 to 55	0 to 15	0 to 5	—	—
11.	¾" to No.4	—	—	—	—	—	—	100	90 to 100	—	20 to 55	0 to 10	0 to 5	—
12.	½" to No.4	—	—	—	—	—	—	—	100	90 to 100	40 to 70	0 to 15	0 to 5	—
13	⅜" to No.8	—	—	—	—	—	—	—	—	100	85 to 100	0 to 30	0 to 10	0 to 5

5.3.1.6 WATER

Water for washing aggregates and for mixing and curing concrete shall be fresh, clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, or other deleterious substances as determined by ASTM D-596 and BS-3148 or equivalent.

The water for curing concrete should have a pH value between 6 to 8 and shall not contain impurities which cause discoloration of concrete. Generally the water fit for drinking is fit for concreting.

Water shall be stored in water tight tanks either of masonry or G.I or M.S sheets so as to be protected from contamination with dust and other foreign matter.

5.3.1.7 ADMIXTURES

(a) Approval Required

Admixtures, including air-entraining admixtures, foaming chemicals and water-reducing admixtures, shall not be used, except with the prior approval of the Engineer-in-Charge.

Before using admixtures in concreting process, trial mixes shall be made to determine the mix design by laboratory testing.

(b) Air-Entraining Admixtures

The source and brand of air-entraining admixtures, if required, shall be proposed by the Contractor and approved by the Engineer-in-Charge. The air-entraining admixture will be an approved substance or compound conforming to the requirements of ASTM C 260, which will produce entrained air in the concrete as hereinafter specified. The air-entraining admixture shall be added to the batch in solution in a portion of the mixing water. This solution shall be batched by means of a mechanical batcher capable of accurate measurement and in such a manner as to ensure uniform distribution of the admixture throughout the batch during the specified mixing period.

(c) Water-Reducing Admixtures

The source, brand, types of suitable water reducing cement dispersing admixtures, if required, shall be proposed by the Contractor and approved by the Engineer-in-Charge. The water-entraining admixture will be compatible with the air-entraining admixture specified above and shall be batched and added to the concrete in the manner specified for the adding of air-entraining admixture but separate from the portion of the mixing water containing the air-entraining admixture. The quantities of water-reducing, cement dispersing admixture to be used shall be in accordance with the instructions of the manufacturers as approved by the Engineer-in-Charge. Water reducing admixture shall conform to the requirements of ASTM C-494.

(d) Foaming Chemicals

The source, brand and types of suitable foaming chemicals, if required, shall be as approved by the Engineer-in-Charge. The foaming agent shall conform to ASTM C-869.

5.3.1.8 WATERSTOPS

a) PVC Water-stops

PVC (polyvinylchloride) water-stops shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinylchloride. 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 and tested it shall have the physical characteristics as shown in Table 5.3(d).

Table 5.3 (d)
Physical Characteristics of PVC Waterstop

Physical Characteristics	Test Method	Typical Values
Ultimate Elongation	ASTM D 638 (CRD C 573)	350 % min
Tensile Strength	ASTM D 638 (CRD C 573)	1750 psi (12.07 Mpa) min
Low Temperature Brittleness	ASTM D 746 (CRD C 570)	No Failure @ - 35 F (-37 C)
Stiffness in Flexure	ASTM D 747 (CRD C 571)	400 psi (2.76 Mpa) min
Specific gravity	ASTM D 792	1.37 max
Hardness, Shore A	ASTM D 2240	70 - 80

b) Metal Water-stops

COPPER:

Copper water-stops shall conform to the requirements of ASTM B-370 and shall have the weight as shown in the Drawings.

STAINLESS STEEL:

Stainless steel water and grout stops shall conform to the requirement of ASTM A-167, Type 302 or 304.

STEEL:

Sheet steel for steel water-stops shall conform to the requirements of ASTM A-366 or ASTM A-569 where no welding is required and to ASTM A-4256 where welding is required.

ALUMINIUM:

Aluminium sheet for water-stops shall conform to the requirements of ASTM B-209.

COPPER:

Copper sheet water-stops shall conform to the requirements of ASTM B-152-97(a).

5.3.1.9 JOINT SEALING COMPOUND

Sealing compound shall be either of the cold application type conforming to ASTM D-1850 or of the single or multiple component type or of the hot poured type conforming to the requirements of ASTM D-1190 or their equivalents.

5.3.1.10 EXPANSION JOINT FILLER

Expansion Joint filler material shall be pre-moulded asphalt impregnated fibre board, to be applied over the full joint-width, except as otherwise indicated on the Drawings, and shall conform to ASTM D-1751 where non-extruding and resilient bituminous type is indicated but where non-extruding and resilient non-bituminous is required the expansion joint filler shall consist of sponge rubber, self-expanding cork or any other material and type as directed by the Engineer-in-Charge, meeting the requirements of ASTM D-1752.

5.3.1.11 NON-SHRINK GROUT

Non-shrink grout of a thickness less than 25mm shall consist of one part cement, one part clean sharp sand and 1:22000 to 1:15000 part of grained aluminium powder containing

non-polishing agent. Non-shrink grout 25mm or more in thickness shall be proportioned as above except that 1.5 parts of 9mm to 6mm (pea-size) gravel shall be added to the mix. The above composition may be varied if so required by the Engineer-in-Charge. In each case, however, the Contractor shall, at his own cost, prepare optimum mix design and conduct testing of the grout composition for strength and non-shrink performance. Pre-mix non-shrink grout from approved manufacturers may also be used.

5.3.2 PROPORTIONING & MIXING OF CONCRETE MIX

5.3.2.1 PROPORTIONING OF INGREDIENTS

- a) The proportioning of the concrete for its ingredients namely cement, sand and coarse aggregates is specified for CSR items on volume basis for the specified use. The proportioning and batching of concrete mix shall accordingly be done on volume basis.
- b) The amount of water used in the concrete shall be so regulated as to secure concrete of a proper consistency and to adjust for any variation in the moisture contents, or grading of the aggregates as they enter the mixer. Water shall not be allowed to be added to undo the stiffening of the concrete resulting from excessive over-mixing or objectionable drying before placing. Uniformity in concrete consistency from batch to batch shall be required. Unless otherwise specified or directed by the Engineer-in-Charge the slump of concrete after it has been deposited, but before it has consolidated, shall have the following values under different situations:

Sr. No.	Purpose	Slump (inches)
1.	Very high strength concrete for pre-stressed concrete sections compacted by heavy vibration.	0
2.	High strength reinforced and pre-stressed concrete section, paving and mass concrete compacted by vibration.	0 – 1
3.	Normally reinforced concrete sections compacted by vibration, hand compacted mass concrete.	1 – 2
4.	Heavily reinforced concrete sections compacted by vibration, hand compacted concrete in normally reinforced slabs, beams, columns and walls.	2 – 4
5.	Heavily reinforced concrete sections compacted without vibration and work where compaction is particularly difficult.	4 – 6

c) **Water Cement Ratio**

The general, the mix design shall provide for water – cement ratios by weight with aggregate at saturated surface dry condition, which will be determined on the basis of producing concrete having suitable workability, density, im-permeability, durability and the required strength without the use of excessive amount of cement.

It is expected that water– cement ratio by weight will vary from 0.45 for concrete in thin sections to 0.65 for mass concrete in severe weather conditions. Maximum permissible water cement ratio will also vary from 0.67 for low strength concrete to 0.38 for 5000 psi at 28 days strength concrete and above.

5.3.2.2 MINIMUM CUBE STRENGTH REQUIREMENT

Unless otherwise specified concrete mixes shall conform to the strength requirements given in the following table:

Nominal Mix	Minimum cube strength required (in psi)				General use
	Laboratory Tests		Work Tests		
	7 days	28 days	7 days	28 days	
1:1:2	4000	6000	3000	4500	In paving.
1:1½:3	3350	5000	2500	3750	For reinforced concrete other than in paving
1:2:4	2700	4000	2000	3000	
1:3:6	-	2500	-	2000	For mass concrete
1:4:8	-	2000	-	1500	For Lean concrete

28 days 6 inches x 12 inches (15cm x 30 cm) cylinder strength corresponding to 28 days cube strength in the Table are given hereunder:

28 days cube strength (Psi)	6" x 12" cylinder strength (Psi)
4500	4000
3750	3000
3000	2200
2000	1500

Lower grade concrete with greater proportions of sand and coarse aggregates could be used as specified. The cube strength for these mixes shall be determined in field for reference.

5.3.2.3 MIXING

The mode of mixing (i.e. hand mixing or machine mixing) shall be as specified and determined by the Engineer-in-Charge keeping in view the size of work.

5.3.2.4 HAND MIXING

Unless otherwise specified or directed, hand mixing shall be done on the following lines:

- a) Wooden batch boxes of one to three cubic feet capacity shall be used. Convenient sizes of these boxes are given below:

Capacity (Cubic feet)	INSIDE MEASURE (Inches)		
	Length	Breadth	Height
1	12	12	12
1¼	15	15	9 ⁵ / ₈
1½	15	15	11½
1¾	15	15	13½
2	18	18	10 ⁵ / ₈
2¼	18	18	12
2½	18	18	13 ³ / ₈
2¾	18	18	14 ⁵ / ₈
3	18	18	16

- b) Hand mixing shall only be done on a smooth watertight platform large enough to allow efficient turning over of the various ingredients both before and after the addition of water.

The platform shall be wooden and rectangular in shape having close fitting joints between the boards or long sheet iron troughs. The platform shall in no case be utilized for storing material other than that required for immediate mixing.

- c) Size of each batch shall be regulated by the proportions of the ingredients. A batch mixed at a time shall not contain more than one bag of cement. The approximate yield of concrete per bag of cement and volume of loose materials for various nominal mixes is given in the following table:

Nominal mix by volume	Volume of fine and coarse aggregate per bag of cement (Cu.ft.)	Yield per bag of cement (Cu.ft.)	Volume of loose materials for 1 bag batch (Cu.ft.)	Minimum size of mixer for 1-bag batch
1:1:2	1¼ : 2 ½	3½	5	3½
1:1½ :3	1⅞: 3 ¾	4½	6⅞	5
1:2:4	2½ : 5	5¾	8¾	7

In case concreting has to be done at a faster speed different gangs of labourers shall prepare different batches at the same time.

- d) The measured quantity of cement shall be placed on top of the measured quantity of fine aggregate and then both of these shall be mixed dry three times or more till they attain a uniform colour. The measured quantity of Coarse aggregate shall then be added and mixed with it. The required quantity of water, which shall be measured or weight for each batch, shall then be added with a rose. The mixture shall be turned over and the process continued at least three times or till the entire mass has become wet and a homogeneous mixture of the required consistency has been obtained.
- e) The re-tempering of concrete or mortar which has partially set (that is remixing with or without additional cement aggregate or water is absolutely prohibited. Under no circumstances shall concrete which has partially hardened be deposited in the work.

5.3.2.5 MACHINE MIXING

a) **Type and Capacity**

All concrete shall be produced in a batching and mixing plant or by means of a mechanical mixer.

The capacity of the plant shall be such that the proposed arrangement will produce adequate quantity of concrete to meet with all the other requirements of these Specifications and the construction schedule. The batched materials shall be thoroughly combined into a uniform mixture before the addition of water and admixtures. The water shall be added gradually and the mixer operated for specified duration of time so as to obtain a thoroughly mixed concrete of uniform colour and quality.

b) **Mixers**

The mixers provided by the Contractor shall be capable of combining the materials into a uniform mixture and of discharging without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer and shall not be recharged before completely discharging the previous batches. Over mixing requiring additions of water will not be permitted. The mixers shall be operated at a drum speed designated by the manufacturer. The mixers shall be cleaned frequently and maintained in satisfactory

operating condition, and mixer drums shall be replaced when worn down more than 10 per cent of their length and or thickness.

c) **Water Batcher**

A suitable water measuring device shall be provided by the Contractor which shall be capable of measuring water within the specified requirements for each batch. The mechanism for delivering water to the mixer shall be such that no leakage will occur when the valves are closed.

d) **Locations**

The concrete plant/mixer shall be installed at the Site at locations selected by the Contractor and approved by the Engineer-in-Charge.

e) **Arrangement**

- (i) Separate bins and compartments shall be provided for each size or type of aggregate and Portland cement. The compartments shall be of adequate size and so constructed that the materials will be maintained separated under all conditions. Batching equipment/arrangement shall be capable of delivering concrete within the following limits of accuracy as shown in Table 5.3(e).

Table 5.3 (e)

Tolerances for Weights of Concrete Batching Ingredients

Material	Percent by weight
Cement	±1%
Water	±1%
Aggregate smaller than 19 mm (3/4 inches)	±2%
Aggregate larger than 19 mm (3/4 inches)	±3%

- ii) For volume batching suitable measuring boxes shall be used. The batching should preferably be for one full bag of cement (50 Kgs.) corresponding to a volume of 1¼ Cu.ft. (0.035 Cu.M.) or such other amount as may be determined by the Engineer-in-Charge as a result of tests of bulking effect of aggregates shall be take into consideration.

f) **Cooling**

Adequate cooling facilities shall be provided to ensure that the temperature of concrete when discharged from the mixers is sufficiently low to meet the temperature requirements as specified in sub-section 5.3.4(c). Cool mixing water, ice, pre-cooled aggregate, shading the stockpiles with roofing or any other arrangements may be used to ensure the pre-cooling of the concrete, subject to the written approval of the Engineer-in-Charge, but approval shall not in any way relieve the Contractor of his responsibility of placing concrete at temperatures at or below the specified limits. The Engineer-in-Charge if required shall order the following to meet the temperature requirements.

1. Avoiding the placement of concrete during the hottest part of day.
2. Placement only at night.

g) **Scales**

Adequate weight and volume batching facilities, as approved by the Engineer-in-Charge, shall be provided by the Contractor for the accurate measurement and control of each of the materials entering each batch of concrete. The accuracy of the weighing equipment

shall conform to the requirements of applicable standards. The weighing equipment shall be arranged so that the concrete plant operator and Engineer-in-Charge can observe the dials or indicators. Volumetric measurements, if approved by the Engineer-in-Charge, shall be made by means of accurate measuring boxes.

h) **Mixing Time**

The mixing periods specified in Table 5.3(f) are based on proper control of the speed of rotation of the mixer in accordance with Plant Manufacturer's recommendation and of the proper introduction of the materials into the mixer. The mixing time will be increased when such increase is necessary to secure the required uniformity, workability and consistency of the concrete. The mixing time for each batch after solid materials are in the mixer drum, provided that all the mixing water is introduced before one fourth of the mixing time has elapsed, shall be as follows:

Table 5.3 (f)
Mixing Periods for Concrete

Capacity of	Mixer Mixing Time (Minutes)
Upto 1.5 cubic metres (2 cu.yds)	2.0
from 1.5 to 2.5 cubic metres (2.0 to 3.25 cu.yds)	2.5

The time for higher capacity mixing shall be according to plant manufacture's recommendation.

5.3.3 CONVEYING

Concrete shall be conveyed from mixer to the place of final deposit as rapidly as practicable, by methods which will prevent segregation or loss of ingredients and in accordance with ACI-304. Any wet batch hopper through which the concrete passes shall be conical in shape. There shall be no vertical drop greater than one metre except where the use of such equipment is approved in writing by the Engineer-in-Charge, in advance of any use. Each type or class of concrete shall be visually identified by placing a coloured tag or marker on the bucket as it leaves the mixing plant so that the concrete may be positively identified and placed in the structure forms in the desired position.

5.3.4 PLACING

(a) **General**

No concrete is to be placed until all the preparatory works have been satisfactorily completed and the reinforcement and embedded items have been checked and approved by the Engineer-in-Charge. Concrete placing shall follow the practice given in ACI-304. No concrete shall be placed until all formwork, reinforcement, installation of parts to be embedded, bracing of forms and preparation of surfaces involved in the placing and the method of placement have been approved by the Engineer-in-Charge. Approval of the method of placement proposed will not relieve the Contractor of his responsibility for its adequacy and Contractor shall remain solely responsible for the satisfactory construction of all work under the Contract. Before concrete is placed, all surface upon or against which concrete is to be placed shall be free from standing water, mud, debris or loose material. All surfaces of forms and embedded material that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed. The surfaces of absorptive

materials against or upon which concrete is to be placed shall be moistened thoroughly so that the moisture will not be drawn from the freshly placed concrete. Concrete shall be worked into the corners and angles of the forms and around all reinforcement and embedded items without permitting the material to segregate. Concrete shall be deposited as close as possible to its final position in the forms. The depositing of concrete shall be regulated so that the concrete may be effectively compacted with a minimum of lateral movement into horizontal layers generally 6 inches to 12 inches for reinforced concrete and 15 inches to 18 inches for mass concrete or as approved by the Engineer-in-Charge. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the structure, nor shall re-tampered concrete be used unless approved by the Engineer-in-Charge. The surfaces of construction joints shall be kept continuously wet for at least eighteen hours during the twenty-four hour period prior to placing concrete except as otherwise directed by the Engineer-in-Charge. All free water shall be removed and the construction joint shall be completely surface dry prior to placement of concrete. All concrete placing equipment and methods shall be subject to approval of the Engineer-in-Charge. Concrete placement will not be permitted, if in the opinion of the Engineer-in-Charge, weather conditions prevent proper placement and consolidation. It is advisable during wet weather to maintain a large slope on any large area of fresh concrete, sufficient to result in drainage of water.

b) Time Interval Between Mixing and Placing

Concrete mixed in stationary mixers and transported by non-agitating equipment shall be placed within thirty minutes after it has been mixed, unless otherwise authorized. When a truck mixer or an agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within 1.5 hours after introduction of the cement to the aggregates. The concrete shall be placed within 30 minutes after it has been discharged. In all cases, concrete shall be placed and compacted well within the initial setting time.

c) Placing Temperature

Placing temperature unless otherwise approved by the Engineer-in-Charge shall conform to the requirements herein specified for thin, moderate and mass sections. The Engineer-in-Charge's determination as to the type of section and applicable placing temperatures shall govern. Concrete shall be placed at temperatures as follows:

THIN SECTIONS:

Concrete for thin sections shall be delivered to the forms at the coolest temperature which is practicable to produce under current conditions but in no case at a temperature in excess of 30°C. Except as otherwise determined by the Engineer-in-Charge, sections to which this provision shall apply shall be less than 20 inches (50 cms) in thickness.

MODERATE SECTIONS:

Concrete for moderate sections shall have a temperature of not more than 21°C when placed. A moderate section will be one that is greater than twenty inches (fifty centimetres) but less than 40 inches (one metre) in thickness.

MASS CONCRETE SECTIONS:

Concrete having a measure of 40 inches (one metre) or more in thickness shall have a temperature not exceeding 18°C.

- d) **Blinding Concrete**
- Where concrete is to be placed on a flat excavated surface or on an excavated surface inclined at not more than IV: 1.75 H, a 3 inches (75 mm) layer of blinding concrete, if not otherwise shown on the Drawings, shall be placed immediately after completion of excavation and cleaning. The upper surface of the blinding concrete shall not be higher than the required cover below the lowest layer of the reinforcing steel. The final excavated level shall be calculated to allow for the 75 mm thickness of the blinding layer.
- e) **Lifts in Concrete**
- Concrete shall be placed in lifts or depths as shown on the Drawings. The placement of concrete shall be carried on at such a rate and in such a manner that formation of cold joints is prevented. Slabs shall be placed in one lift, unless otherwise authorized or directed. In walls, lifts shall terminate at such levels as shall conform to structural details. Where slabs and beams are placed continuously with walls and columns, the concrete in walls and columns shall have been in place for at least two hours, or for a longer period when directed by the Engineer-in-Charge, before placing concrete in the slabs and beams. The top surface of vertically formed lifts shall be generally levelled. The concrete in columns shall be placed in one continuous operation, unless otherwise authorized. In general, the construction joints in beams and slabs shall be located as shown on the Drawings and concrete shall be placed in the sequence indicated on the Drawings or as authorized by the Engineer-in-Charge. The maximum differential in height between the various pours of the structure shall be as shown on the Drawings or as directed by the Engineer-in-Charge.
- f) **Elapsed Time between Placement of lifts**
- Except as otherwise approved on the basis of lift drawings submitted by the Contractor, a minimum of 72 hours shall elapse between the placing of successive lifts of walls and thin sections and 120 hours shall elapse between placing lifts of moderate and mass sections. Thin, moderate and mass sections are defined in sub-section 5.3.4(c).
- g) **Time between Adjacent Pours**
- The time between adjacent pours shall be defined as the time elapsing from the end of the striking off of one pour to the start of placing the next pour. The minimum time elapsing between adjacent pours shall be five days for thin and moderate sections and fourteen days for mass section.
- h) **Concrete above and Around Openings**
- If concrete is placed monolithically around openings having vertical dimensions greater than 0.6 metres, or if concrete in floor slabs or other similar parts of structures is placed monolithically with supporting concrete, the following instructions shall be strictly observed:
- Placing of concrete shall be delayed from one to three hours at the top of openings and at the bottom of bevels under floor slabs, or other similar parts of structure when bevels are specified and at the bottom of such structural members when bevels are not specified; but in no case shall the placing be delayed so long that the vibrating unit will not readily penetrate on its own weight in the concrete placed before the delay. When consolidating concrete is placed after the delay, the vibrating unit shall penetrate and re-vibrate the concrete placed before the delay.

- The last 0.6 metres or more concrete placed immediately before the delay shall be placed with as low a slump as practicable and special care shall be exercised to effect thorough consolidation of the concrete.
- The surface of concrete where delays are made shall be clean and free from loose and foreign material, when concrete placing is started after the delay.
- Concrete placed over openings and in slabs and other similar part of structures shall be placed with as low a slump as practicable and special care shall be exercised to effect thorough consolidation of the concrete.

i) **Concrete for Second Stage and Block-outs**

Blockouts for equipment and fittings and for such other work as indicated or directed shall be provided as indicated on the Drawings. After the said equipment and fitting have been installed and adjusted in their final location, the block out recesses shall be filled with concrete. Before installing the components to be embedded in block out concrete and before depositing any block out concrete, the concrete surfaces of the block out shall be cleaned in the manner specified for cleaning construction joints.

Second stage concrete for filling the openings left for the installation of equipment and fittings shall be anchored to the first stage concrete. The size and spacing of the concrete fixing sockets, if any, to be embedded in the first stage concrete shall be subject to the approval of the Engineer-in-Charge. Different components of structures to be built from second stage concrete like partition walls, slabs, beams and other parts of structure indicated on Drawings as second stage shall be connected to the first stage concrete through dowels. Dowels not shown in first stage concrete Drawings shall be placed and fixed in position by drilling holes in concrete as approved by the Engineer-in-Charge.

j) **Placing Concrete through Reinforcement**

In placing concrete through reinforcement, care shall be taken that no segregation of the coarse aggregate occurs.

In certain cases, like the bottom of beams and slabs, the congestion of steel near the forms may make placing difficult. In such cases, as decided by the Engineer-in-Charge, a layer of mortar of a composition compatible with the required concrete strength shall be first deposited to cover the surface to a depth of 15mm.

k) **Vibration of Concrete**

Recommended Practice given in ACI 309 shall be followed for concrete consolidation. Concrete shall be compacted with mechanical or electrical vibrating equipment supplemented by hand spading and tamping. In no case shall vibrators be used to transport concrete inside the forms. The vibrating equipment shall be of internal type and shall at all times be adequate in number of units and power of each unit to properly consolidate all the concrete. Form or surface vibrators shall not be used unless specifically approved. The intensity (amplitude) of vibration shall be sufficient (frequency not less than 6,000 impulses per minute) to produce satisfactory consolidation. The duration of vibrations shall be limited to that necessary to produce satisfactory consolidation. Excessive surface working will not be permitted.

5.3.5 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS

a) **Expansion and Contraction Joints**

Expansion and contraction joints shall be provided at the locations indicated and according to the details shown on the Drawings. In no case shall any fixed metal, embedded in concrete, be continuous through an expansion or contraction joint.

Where indicated on the Drawings, expansion joint filler joint sealing compound, GI, Aluminium & Copper sheets shall be installed using materials of the type and quality indicated.

b) **Construction Joints**

GENERAL:

As soon as a lift is completed, the top surface of concrete and reinforcing dowels shall be immediately and carefully protected from any condition that may damage the concrete surface and the dowels.

CLEANING:

Horizontal construction joints on lifts with relatively open and accessible surfaces shall be prepared for receiving the next lift by cleaning with either wet sandblasting or by air-water cutting. Approved wet sandblasting equipment shall be provided. If the surface of a lift is congested with reinforcing steel and is relatively inaccessible or if for any other reason it is considered undesirable to disturb the surface of a lift before it has hardened, surface cutting by means of air-water jets will not be permitted and the use of wet sandblasting will be required.

AIR WATER CUTTING:

Air-water cutting of a. construction joint shall be performed when approved by the Engineer-in-Charge. The surface shall be cut with a high-pressure air-water jet to remove all laitance and to expose clean, sound aggregate, but not so as to undercut the edges of the larger particles of the aggregate. The air pressure used in the jet shall be 0.7 MPa plus or minus 10% (100 psi) and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. The surface shall again be washed with an air-water jet while the concrete is still green, say well within 6 hours of concreting, (depending upon the atmospheric conditions of humidity and temperature) prior to placing the succeeding lift. Where necessary to remove accumulated laitance, coatings, stains, debris and other foreign material, wet sandblasting will be required immediately before placing the next lift to supplement air-water cutting. When approved by the Engineer-in-Charge, a retarder may be applied to the surface of the lift in order to prolong the period of time during which airwater cutting is effective. Prior to receiving approval, the Contractor shall furnish technical data and samples of the retarder to be used and shall demonstrate the method to be used in its application.

WET SANDBLASTING:

When employed in the preparation of construction joints, wet sandblasting shall be performed immediately before placing the following lift. The operation shall be continued until all laitance, coating, stains, debris and other foreign materials are removed. The surface of the concrete shall then be washed thoroughly to remove all loose material.

JOINTS:

Vertical construction joints shall be prepared similar to the horizontal construction joints. Where allowed by the Engineer-in-Charge, the inner surface of the formwork may be coated with an 'approved set-retarder to facilitate the preparation of the vertical construction joint.

WATER DISPOSAL:

The method used in disposing of water employed in cutting, washing and rinsing of concrete surfaces shall be such that the waste water does not stain, discolour, or effect

exposed surfaces of the structure. Methods of disposal shall be subject to approval by the Engineer-in-Charge.

5.3.6 INSTALLATION OF WATER STOPS

a) **General**

Except as otherwise shown on the Drawings, water-stops shall be installed with an approximately equal width of material embedded in concrete on each side of the joint. Water stops shall be sealed to other cut off systems as shown on the Drawings or as directed by the Engineer-in-Charge. All water-stops shall be installed and carefully positioned so as to form a continuous water tight diaphragm in each joint. All splices shall be neat with the ends of the joined materials in true alignment.

Concrete shall be carefully placed and vibrated around water stops to ensure maximum concrete imperviousness and density, the complete filling of the forms in the vicinity of the waterstop and complete contact between the concrete and all surfaces of water stop.

b) **Metal Water-stops**

Copper, stainless steel, steel and aluminium water-stops shall be installed in joints at the locations shown on the Drawings. The thickness, shape, dimensions and splicing of metal water-stops shall be as shown on the Drawings or as approved by the Engineer-in-Charge.

c) **PVC Water-stops**

Splices in the continuity or at the intersections of run of PVC water-stops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations or as directed by the Engineer-in-Charge. A thermostatically controlled electric source of heat shall be used to make all splices. The correct temperature at which splices should be made will differ with the material used but should be sufficient to melt but not char the plastic. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the water-stop shall be used to reform the ribs at the splices. The continuity of the characteristic components of the cross-section of the water-stop design (ribs, tubular center axis, protrusions, and the like) shall be maintained across the splice. The splices joints shall be tested in accordance with the applicable standards and as directed by the Engineer-in-Charge.

5.3.7 CURING

a) **General**

All concrete including concrete repair work shall be cured by an approved method or combination of methods in accordance with ACI 308. The Contractor shall have all equipment and materials needed for adequate curing and protection of the concrete on hand and ready to use before actual concrete placement begins. Means shall be provided for the protection of concrete from the sun, drying winds and traffic until the specified curing has been completed.

The curing medium shall be applied so as to prevent loss of moisture from the concrete. Concrete shall be protected from heavy rains for 24 hours. All concrete shall be adequately protected from damage. No fire or excessive heat, including the heat resulting from welding, shall be permitted near or in direct contact with the concrete at any time. All galleries, conduits and other formed openings through the concrete shall be closed during the curing period.

If during the specified minimum period of curing, the surface temperature of the concrete falls below 10°C, the period of curing shall be extended to allow the concrete to reach

sufficient maturity. The period of extension shall be as approved by the Engineer-in-Charge.

b) **Moist Curing**

Concrete shall be moist-cured maintaining all surfaces continuously (not periodically) wet for 14 days immediately following the placing or until covered with fresh concrete. Precast elements shall also be water-cured for 14 days. Curing water shall be removed without allowing stagnant pools of water to form on the exposed lift surface. Water for curing shall comply with the applicable requirements of Sub-section 5.3.1.6 - Water. Where forms of tongue-and groove or shiplap sheeting are used and are left in place during curing, the sheathing shall be kept wet at all times. When in contact with concrete, steel forms shall be kept wet. Horizontal construction joints and finished horizontal surfaces cured with sand shall be covered with a minimum uniform thickness of 5 cm of sand and kept continuously saturated with water.

c) **Liquid Curing Membrane**

An approved curing compound conforming to ASTM C-309 shall be applied in accordance with the manufacturer's recommendations immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other material is to be bonded unless it is proven that the curing compound will not prevent bond or unless positive measures are taken to remove it completely from such areas.

5.3.8 REPAIR OF CONCRETE

a) **General**

Concrete that is damaged from any cause; concrete that is honeycombed, fractured, or otherwise defective; and concrete which, because of excessive surface depressions, must be excavated and built up to bring the surface to the prescribed lines; shall be removed and replaced with dry pack mortar, or concrete, as hereinafter specified. The excavation to firm surface shall be carried carefully by hand or by using mechanical means without damaging the firm surface on which material is to be placed. Repair of concrete shall be performed only by skilled workmen and within 24 hours of removal of forms. The Contractor shall keep the Engineer-in-Charge advised as to when repair of concrete will be performed. Unless an inspection is waived in each specific case, repair of concrete shall be performed only in the presence of the Engineer-in-Charge. Repairs shall be made in accordance with the procedures approved by the Engineer-in-Charge or his representative.

b) **Material**

All materials used in the repair of concrete specified hereunder shall conform to the applicable requirements of the Specifications for Section 5 – Plain & Reinforced Concrete.

c) **Protrusions**

Where bulges and abrupt irregularities protrude outside the specified limits on formed surfaces not to be concealed permanently, the protrusions shall be reduced by bush-hammering and grinding so that the surface irregularities are within the specified limits in accordance with the provisions of Sub-Section 5.3.9.

d) **Depressions**

GENERAL:

All fillings for depressions shall be bonded tightly to the surfaces of holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been

cured and have dried. All fillings in surfaces of structures prominently exposed to public view shall contain sufficient white Portland cement to produce the same colour as that of the adjoining concrete. Repairs shall be made with non-shrink grout, guniting or dry pack filling except where repairs with epoxy concrete and/or epoxy mortar are directed to be made by the Engineer-in-Charge. Concrete, mortar, grouting, guniting or dry pack mortar filling as the case may be shall each be mixed in proportions approved by the Engineer-in-Charge to produce a repair at least equivalent in strength density and durability to the concrete in which the repair is required and shall match with the adjacent surfaces in texture, colour and shade.

CONCRETE FILLING:

Concrete filling shall be used for holes extending entirely through concrete sections; for holes in which no reinforcement is encountered and which are greater in area than 10 square inches (0.1 square metre) and deeper than 4 inches (10 cm); and for holes in reinforced concrete which are greater than 5 square inches (0.05 square metre) in area and which extend beyond the reinforcement.

MORTAR FILLING:

Mortar filling (1 cement and 1 sand), placed under impact by use of a mortar gun, may be used for repairing defects on surfaces, not exposed to public view where the defects are too wide for dry pack filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest to the surface.

DRYPACK MORTAR FILLING:

Dry pack mortar fillings shall be used for filling holes having a depth nearly equal to, or greater than, the least surface dimension; for narrow slots cut for repair of cracks; for grout pipes recesses; and for tie rod fastener recesses as specified. Dry pack mortar shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section. If removal of the ends of form ties results in recesses, the recesses shall be filled with dry pack mortar provided that filling of recesses in surfaces upon or against which fill material or concrete is to be placed will be required only where the recesses are deeper than 25 mm in walls less than 300 mm thick.

SURFACE FINISHES OF REPAIRED AREAS:

The Contractor shall correct all imperfections on the concrete surface as necessary to produce surfaces that conform to the requirements specified for the adjacent area. Fins and encrustations shall be neatly removed from the surfaces.

5.3.9 FINISHES AND FINISHING

a) General

Allowable deviations from plumb or level and from the alignment, profile grades and dimensions shown on the Drawings or specified. Tolerances are defined as tolerances and are to be distinguished from irregularities in finish as described herein. The classes of finish and the requirements for finishing of concrete surfaces shall generally be as specified herein or as indicated on the Drawings. Finishing of concrete surfaces shall be performed only by workmen who are skilled concrete finishers.

The Contractor shall keep the Engineer-in-Charge informed as to when finishing of concrete will be performed. Unless inspection is waived in each specific case, finishing of concrete shall be performed only in the presence of the Engineer-in-Charge. Concrete surfaces will be tested by the Engineer-in-Charge where necessary to determine whether surface irregularities are within the limits hereinafter specified. Surface irregularities are classified as abrupt or gradual. Offsets caused by displaced or misplaced form sheathing

or lining or form sections or otherwise defective form lumber will be considered as abrupt irregularities, and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities and will be tested by the use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 5 ft. (1.5 metres).

The classes of finish for concrete surfaces shall be as shown on the Drawings or as directed by the Engineer-in-Charge. No grinding will be required on formed surfaces other than that necessary for repair of surface imperfections as specified herein.

b) **Ordinary Finish (OF)**

Ordinary finish (OF) applies to surfaces upon or against which fill material or concrete is to be placed. If unformed, the finishing operation shall consist of sufficient levelling and screeding to produce even uniform surfaces. When formed, the surfaces require no treatment after form removal except for repair of defective concrete and filling of holes left by the removal of fasteners from the end of the tie rods as required under Sub-section 5.3.8 -Repair of Concrete. Correction of surface irregularities shall be required for depressions only and only for those which exceed 25 mm when measured as described in Sub-section 5.3.9(a) above.

c) **Rough Concrete Finish (RC)**

Rough concrete finish (RC) applies to surfaces which are intended to receive tiles, metallic lining or other applications as indicated on the Drawings. After consolidation and levelling of the concrete to the specified tolerances, the surface shall be roughened with stiff brushes or rakes before final set. Where rough concrete finish is specified for wall surfaces, the same shall be obtained by use of formwork suitable to produce the required finish. Surface irregularities measured as described in Sub-section 5.3.9(a) General, shall not exceed 6mm for floors and 3mm for walls.

d) **Ordinary Slab Finish (OS)**

Ordinary slab finish (OS) applies to floor surfaces which are not intended to receive any floor coverings. After the concrete has been placed, consolidated, struck-off and levelled, and its surface has stiffened sufficiently, floating shall be performed by use of hand or power driven equipment, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Floating shall be continued until a small amount of mortar without excess water is brought to the surface so as to permit effective trowelling. Steel trowelling shall be started when the surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface. Steel trowelling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Surface irregularities measured as described in Sub-section 5.3.9(a) General, shall not exceed 6mm for abrupt irregularities and 12mm for gradual irregularities and 12mm for gradual irregularities.

e) **Fair Faced Finish (FF)**

Fair Finish (FF) shall be applied to all exposed surfaces of walls and ceilings which are not to be covered by any other finish. Surface irregularities shall not exceed 3mm for abrupt irregularities and 6mm for gradual irregularities, when measured as described in Sub-section 5.3.9(a). All abrupt irregularities and all gradual irregularities in excess of 6mm shall be reduced by grinding to conform to the specified limit for gradual irregularities.

5.4 CONCRETE REINFORCEMENT

5.4.1 GENERAL

The work shall include providing, cutting, bending, fabricating, assembling and placing of all concrete reinforcement including rods and fabric in accordance with Drawings, Specifications and Standards as referred hereunder.

5.4.2 RELATED WORKS

Section 5.3 - Plain and Reinforced Concrete.

Section 5.5 - Concrete Formwork

5.4.3 SUBMITTALS

The Contractor shall submit the following to the Engineer-in-Charge for his approval/record before execution of work:

- a) Shop Drawings for fabrication, bending and placement of concrete reinforcement. ACI 315 shall be complied with showing bar schedules, stirrup spacing, diagrams of bent bars, arrangement of concrete reinforcement and special reinforcement required for openings through concrete structures.
- b) Samples of materials as specified and as otherwise may be requested by the Engineer-in-Charge including names, sources and descriptions as required.
- c) Mill certificates or laboratory test reports as required.

5.4.4 TOLERANCES

Cutting for all bars shall be within + 1 inch(+ 25 mm).

Bending and placement tolerances for overall or an internal dimension of a bent bar shall be as given in Table 5.4(a).

Table 5.4 (a)
Bending & Placement Tolerances

Description	Tolerances	
	Plus	Minus
<u>Bending</u>		
Bars upto 1.00 meters long	5 mm	5 mm
Bars 1.00 to 2.00 meters long	5 mm	10 mm
Bars over 2.00 meters long	5 mm	25 mm
<u>Placement</u>		
Concrete cover to formed surfaces	5 mm	5 mm
Minimum spacing between bars	5 mm	5 mm
Top bars in slabs and beams		
- Members 200 mm deep or less	5 mm	5 mm
- Member more than 200mm but not over 600mm deep	10 mm	10 mm
- Member more than 600mm deep	25 mm	25 mm

5.4.5 DELIVERY AND STORAGE

- a) All reinforcement bundled, tagged and marked with complete identification shall be delivered at Site.
- b) Reinforcement shall be stored at Site clear of ground and protected from mud and other deleterious materials.

5.4.6 MATERIALS

- a) Concrete reinforcement of diameter smaller than 35 mm shall be hot rolled deformed steel bars conforming to ASTM Designation A 615 and shall have a minimum yield strength of 275 MPa (40,000 psi). If specified plain mild steel conforming to BS 4449 shall be used.
- b) Steel bars of a high strength, if required, shall have a minimum yield strength of 415 MPa (60,000 Psi) and shall conform to ASTM A-615 or PS 605.
- c) Tor steel shall conform to the applicable British Standard.
- d) Mesh reinforcement shall be welded wire fabric conforming to the requirements of ASTM A-185 or BS 4482 and 4483.
- e) Supports, spacers or ties required shall conform with the Specifications and Standards for main reinforcing steel as per (a) & (b) above.
- f) Binding wire shall be 1.6 mm dia (16 gauge) soft iron wire.

5.4.7 EXECUTION

a) Preparation

The Contractor shall furnish, cut, bend, and place all steel reinforcement including rods and fabric, as indicated on the Drawings or otherwise required. All reinforcement when surrounding concrete is placed, shall be free from loose flaky rust and scale, and free from oil, grease or other coating which might destroy or reduce its bond with the concrete. All placing and fixing shall be in accordance with Drawings furnished or approved by the Engineer-in-Charge. The use of high tensile cold worked reinforcement bars for the transmission of current for welding shall not be permitted. All reinforcement, including dowels, remaining exposed in the work shall be suitably protected against corrosion by a thick coat of cement slurry until embedded in concrete.

b) Cutting and Bending

The Contractor shall ensure that the bars do not get cracked or damaged during bending and fabrication.

Steel reinforcement may be mill or field cut and bent. All bending shall be in accordance with ACI 315 and by approved machine methods. When bending is required, it shall be performed prior to embedding the bars in the concrete. In all such cases, the bars shall be cold bent. Bending or straightening of bars partially embedded in set concrete shall not be permitted except in isolated cases where corrective action or a field change is required and is specifically approved by the Engineer-in-Charge.

c) Spacing of Bars

The spacing of bars shall be as shown on the Drawings or as directed in writing by the Engineer-in-Charge. The variation from indicated spacing, provided that the total area of reinforcement is in accordance with the Drawings, shall be as per Table 5.4(a).

d) Concrete Cover to Reinforcement

The cover for all main reinforcement shall conform to the dimensions shown on the Drawings and in no case less than ½ inch or diameter of the bar which ever is more. The protective covering shall not be less than, and shall not exceed by more than 6 mm the values specified on the Drawings. The dimensions, as shown on the Drawings, indicate the clear distance from the edge of the main reinforcement to the concrete surface. The concrete covering of stirrups, spacer bars, and similar secondary reinforcement may be reduced by the diameter of such bars.

e) **Wire Fabric**

Wire Fabric of specified gauge and mesh shall be used where shown on the Drawings. To provide spacing between mesh and surface receiving mortar or concrete, hooked bolts or studs, anchors and soft iron wire not less than No. 18 U.S. Standard gauge shall be used.

f) **Splicing**

Except as otherwise shown on the Drawings or specified herein, all splices, lengths of laps, splice locations, placement and embedment of reinforcement shall conform to the applicable requirements of ACI 318. All splices and locations of laps in reinforcement shall be as shown on the Drawings or as directed by the Engineer-in-Charge. Lapped ends of bars may be placed in contact and securely wired or may be separated sufficiently to permit the embedment of the entire surface of each bar in concrete.

No welding, including tack welds, of reinforcing bars upto 35 mm in diameter shall be permitted unless shown on the Drawings or authorised in each case by the Engineer-in-Charge. Except as otherwise specifically shown on the Drawings, all reinforcing bars exceeding 35 mm in diameter shall be spliced by butt welding. Butt welding shall conform to the requirements of AWS D.12.1. All welds shall develop the full strength of the smaller bar. Concrete shall be protected from heat during welding operations.

Splicing of the reinforcing bars by approved mechanical methods such as cad weld splices or other splices using positive connectors (mechanical splicing) shall be adopted where directed by the Engineer-in-Charge.

g) **Supports**

All reinforcement shall be secured in place by use of concrete supports. Chairs, spacers, or ties may be of metal or as approved by the Engineer-in-Charge. Such supports shall be of sufficient strength to maintain the reinforcement in place throughout the concreting operations. Concrete supports shall be manufactured of the same concrete strength as used in the structure to be concreted.

h) **Embedded Items**

Before placing concrete, care shall be taken to determine that all embedded items are properly placed as required under the Specifications and are firmly and securely fastened in place as indicated on the Drawings or as directed by the Engineer-in-Charge. Embedded items shall be free from oil and other foreign matter such as loose coatings of rust, paint and scale. The embedding of wood or other perishable materials in concrete is prohibited unless specifically authorized or directed.

5.5 CONCRETE FORM WORK

5.5.1 GENERAL

The work shall include design, erecting, supporting, bracing and maintaining form work so that it will safely and rigidly support all vertical and lateral loads encountered during construction. The extent of formwork is indicated by the concrete work shown on the Drawings.

Unless otherwise specified, no separate measurement or payment shall be made for "Providing Erection and Removal of Formwork" as specified herein, as all cost thereof shall be considered to be included in the Contract unit prices for the various concrete items requiring formwork.

5.5.2 RELATED WORK

Section 5.3 - Plain and Reinforced Concrete

Section 5.4 - Concrete Reinforcement

5.5.3 SUBMITTALS

The Contractor shall submit the following to the Engineer-in-Charge for his information/review:

a) **Manufacturer's Data**

Two copies of manufacturer's data and installation instructions for proprietary materials including form coatings, manufactured form systems, ties and accessories.

b) **Shop Drawings**

Shop Drawings for fabrication and erection of architectural finished concrete surfaces as shown on the Drawings or specified.

General construction for forms including jointing of special formed joints or reveals, location and pattern of form tie placement and other items which affect the exposed concrete visually shall be shown on these Shop Drawings. However, the Engineer-in-Charge's review will be for general architectural and engineering applications and features only. Design of formwork for structural stability and sufficiency is the Contractor's responsibility.

5.5.4 FORM MATERIALS

a) **Form liners for Plain Concrete Finish**

TIMBER/PLYWOOD:

New Plywood 19 mm or timber planks 25 mm thick with continuous support for edges parallel to framing shall be provided. Timber form shall be well seasoned and free of loose knots.

Other Materials:

Approved type forms made of steel, plastic, or other suitable materials may be used in lieu of timber planks/plywood, provided the formed surfaces obtained conform to the requirements of finishes specified for the concrete surfaces.

Re-use of Wood Forms:

Projecting nails shall be withdrawn, concrete cleaned off, re-oiling done and Engineer-in-Charge's approval obtained before re-using the wood forms.

The steel formwork surface in contact with concrete shall be free of rust.

b) **Form Ties**

Form ties shall be snap ties. Sample for Engineer's approval shall be submitted before ordering. Spacing of ties and the rate of placement of concrete shall be consistent with the strength of ties. The Contractor must obtain approval prior to use of any special ties for metal forms.

c) **Form Coatings**

Commercial formulation form-coating compounds shall be provided that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond, painting or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds.

5.5.5 INSTALLATION

a) **General**

Forms shall be so constructed that the tolerances specified in ACI 347.203.1 are met. Openings, offsets, chamfers, blocking and other features as required on the work shall be provided. Easy removal of forms without damage to concrete surfaces shall be provided

for. Formwork shall be kept clear of wood chips, clogs, and other deleterious material. All concrete

surfaces shall be formed. Earth cuts shall not be used as forms for vertical surfaces of concrete work unless approved by the Engineer-in-Charge.

b) **Forms**

The formwork shall conform to the shape, lines and dimensions as shown on the Drawings and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete, and shall be sufficiently tight to prevent loss of liquid from the concrete. Unless otherwise specified, chamfer strips shall be placed in the corners of forms to produce bevelled edges on permanently exposed surfaces. Interior corners on such surfaces and the edges of the formed joints will not require bevelling unless required on the Drawings. Back joints with extra studs or grits shall be provided to maintain true, square intersections. Extra studs, washers and bracing shall be used as required to prevent bowing of forms between studs.

Reusable steel forms of approved design may be used for cast-in- place concrete.

c) **Form Ties**

Form ties shall be provided at exposed surfaces. Ties shall be set in straight rows and evenly spaced. Prior approval shall be obtained if any special ties for metal forms are to be used.

d) **Form Release Agents**

Form release agents shall be applied in accordance with manufacturer's instructions with special attention to rate and method of application.

5.5.6 REMOVAL OF FORMS

Forms for various parts of the structure shall not be removed before the specified time has elapsed after placing the concrete. Consideration shall be given to the weather and other conditions influencing the setting of concrete, curing, and materials in the mix. The exact time shall be determined by the Engineer-in-Charge and will be dependant on curing conditions and the prevalent temperature.

Beams and Slabs	14 days
Columns and Wall Faces	24 hours
Concrete Pedestal	24 hours
Sides of Beams, Caps, and Other Parts	24 hours

Personnel and concrete work shall be protected by re-shoring, if required.

5.5.7 COORDINATION

Formwork shall be coordinated with the work of other trades as required for installation of inserts, conduit pipe sleeves, drains, hangers, supports, anchors and similar items. Embodiments shall be secured in position before concrete is poured. Sufficient time shall be allowed between erection of forms and placing of the concrete to allow various trades to install their work properly.

5.5.8 RE-USE OF FORMS

The forms that will provide surfaces of same quality as original shall only be reused.

5.6 PRECAST CEMENT CONCRETE

5.6.1 GENERAL

Unless otherwise specified, or directed by the Engineer-in-Charge, precast units shall be prepared as shown on the approved Drawings according to the following specification:

5.6.2 PRECASTING FLOOR

In laying out the work yards the Contractor shall provide a pre-casting floor of 3 to 1 concrete-in-mass at least 155 Cms thick to be laid over the entire floor area where pre-casting is to be done. The surface of the floor shall be finished perfectly true and level with a steel trowelled finish. Precautions shall be taken to prevent settlement of the floor. Should settlement take place the floor shall be re-laid or other means adopted to reinstate the level surface before it is used again. During the time the floor is in use it shall be kept true, level, clean and dry. Drains shall be provided to drain away the surplus water quickly, and sufficient space shall be provided between the various moulds to allow working room for handling them and cleaning debris between the various moulds to allow working.

5.6.3 MOULDS

Unless otherwise specified, the moulds in which the concrete is precast shall consist of mild steel and shall not be less than 5 mm thick for small items and 6 mm thick for large items, and suitable arrangements shall be made to prevent them from bulging. In all cases suitable precautions shall be taken to maintain the mould vertical, rectangular and with true faces during the time concrete is being filled in and packed. Core pieces of the required shapes to form chamfers, radii, joggle recesses, cavities, tongues, grooves, and other recesses or chassis shall be provided and firmly attached to the inside faces of the moulds. Wooden moulds may be used for small non-repetitive items.

5.6.4 DESIGN OF MOULDS AND LIFTING APPARATUS TO BE APPROVED

The general arrangements of the floor with its mixing machines, methods supplying materials to the machines and transporting concrete from them and the detail designs of the moulds shall be duly approved by the Engineer-in-Charge. Methods of lifting precast concrete shall also be approved by the Engineer-in-Charge.

5.6.5 SETTING UP MOULDS

The floor shall be thoroughly cleaned and dried and cleared of all cement, scum and debris before setting up the moulds. The inside faces of the moulds shall be thoroughly cleaned and, if necessary, scraped. The mould shall be set absolutely square and vertical. Their inside faces and the floor shall be coated with the vegetable oil or other parting agent duly approved so that concrete does not stick to them. The moulds shall be replaced when required, and the various parts shall be checked from time to time to see that no distortion or alteration in size has occurred.

5.6.6 DEPOSITING CONCRETE IN MOULDS

Concrete shall be transported from the mixing machine to the moulds as quickly as possible and shall be deposited and spread in them in layers. Each batch of concrete shall be well worked in and thoroughly packed against the faces of the moulds. On the completion of each block, its top surface shall be well beaten down and struck off true and level by means of long straight edge and finally floated off with supply of concrete shall be continue and the item shall be finished off complete in one operation. All precast concrete shall be kept continuously watered for a period of at least 28 days after casting.

5.6.7 REMOVAL OF MOULDS

When the concrete has set sufficiently, the sides and ends of a mould shall be slacked off and eased away from the face of the green concrete to allow the circulation of air but this shall not be done till twenty-four hours have elapsed since concreting was completed, except when items have hollow faces.

5.6.8 PRECAST CONCRETE NOT SQUARE OR HONEY COMBED.

If the sides or ends of any precast concrete are not true, as a result of the bulging of the mould or faulty setting, all such rounding or inequalities shall be dressed off neatly and accurately by masons so as to produce true and even faces when it is set in position. If honey comb exists in a slight degree only it shall be stopped neatly, carefully with 2 to 1 cement mortar rubbed in with dry sand by mean of a hand float fair with the general face of the block. Precast concrete that is irreparably out of square or badly honey combed shall not be accepted for use in the permanent work.

5.6.9 BROKEN OR DAMAGED PRECAST CONCRETE

Broken or damaged precast concrete shall not be allowed to be set anywhere in the permanent work unless approved in writing by the Engineer-in-Charge and provided that the Concrete shall be good and sound. If any reducing collar or ordinary collar of hume pipe is damaged, it shall be replaced or repaired to its original position by the Contractor as per Approved Drawings or as directed by the Engineer-in-Charge.

5.6.10 LIFTING AND DATING PRECAST CONCRETE.

No precast concrete shall be lifted off the floor till at least seven days have elapsed after pre-casting it. Its date of manufacture shall be legibly written on the top directly after it has been floated off and finished.

5.6.11 STACKING PRECAST CONCRETE.

The precast concrete after being cured shall be placed in stacks to mature and air space shall be left around each one of them.

5.6.12 DATE OF USING

No precast concrete shall be set in the permanent work unless four weeks have elapsed since its date of manufacture.

5.6.13 OTHER RESPECT

In all other respect, precast concrete shall conform to Specifications for Plain & Reinforced Concrete.

5.7 FOAM CONCRETE

The structural lightweight concrete shall be of specified grade but for thermal insulation the concrete shall be low strength foam concrete and density as specified. Cement sand mortar in 1:2 ratio and admixture of foaming chemicals as approved by the Engineer-in-Charge shall be used. The amount of different ingredients needed to develop a certain density shall be according to the recommendations of the manufacturer for foaming agent and shall be determined by trial mixes under instructions of the Engineer-in-Charge. All materials and the producing, forming, placing, curing and repairing of the foam concrete shall be in accordance with the applicable requirements of this Plain and Reinforced Concrete Section.

5.8 MEASUREMENT & PAYMENT

5.8.1 GENERAL

All measurements & payments shall be for completed work within the neat lines shown on drawings unless otherwise specifically directed.

No measurement and payment shall be made for the under-mentioned specified works for reinforcement. The cost thereof shall be deemed to have been included in the unit rate of the respective items of the BOQ.

- Providing and installing of chairs, supports, hooks, spacers, binding wires and laps not shown on the Drawings.
- Wastage and rolling margin

Measurement shall be made in tonnes of reinforcing steel acceptably placed on the basis of the lengths of bars installed in accordance with the approved Drawings or bar schedules or as directed by the Engineer-in-Charge. Lengths of each size of bars shall be converted to weights by the use of the unit weights per linear metre for each size as per ASTM A-615 or BS 4449 Standards as approved by the Engineer-in-Charge. Steel in laps indicated on the Drawings and as required by the Engineer-in-Charge will be measured for payment.

5.8.2 COMPOSITE RATE

The measurement and payment for the items of the work of Brickwork hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

5.8.3 Labour Rate

The measurement and payment for the items of the work of Brickwork hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

5.8.4 QUANTIFICATION

The unit of measurement shall be measured as mentioned below in accordance with corresponding CSR items.

1. For Volumetric items, the unit of measurement shall be cubic meter or cubic foot .Following items of CSR are measured in the above mentioned criteria;
Item No.: 5-1 to 5-27, 5-29 and 5-45 to 5-49
2. For surface area items, the quantity of work shall be measured by surface area. Following items of CSR are measured according to this criteria;
Item No.: 5-28, 5-35, 5-36, 5-40 and 5-42
3. For linear items, the quantity of work shall be measured linearly along centre line of structure. Following items of CSR are measured according to this criteria;
Item No.: 5-38 and 5-39x
4. For Mass items, the unit of measurement shall be Kilogram or Pounds. The following Items of CSR shall be measured according to this criteria;
Item No.: 5-31, 5-32, 5-34
5. For Weight items, the unit of measurement shall be Tonne or Tons. The following Items of CSR shall be measured according to this criteria;
Item No.: 5-30, 5-43, 5-44