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18. LINING OF CANALS

18.1 SCOPE

This Section covers lining of earthen canal with a layer of any of the followings as specified on drawings and approved by the Engineer-in-Charge:

- a) Asphalt/Bitumen spray
- b) Clay Bricks or Clay Tiles
- c) Concrete

The Contractor shall perform the work as specified.

18.2 ASPHALT/BITUMEN MEMBRANE

18.2.1 MATERIALS

- a. Asphalt/bitumen grade 60/70 or as otherwise specified. The asphalt/bitumen is sprayed in place to form the impervious membrane.
- b. Protective material like earth, gravel etc.

18.2.2 FORMATION OF MEMBRANE

- i. The thickness of Asphalt/bitumen membrane shall be as specified.
- ii. The canal bed on which membrane is to be placed should be over excavated to allow the placement of membrane and protective material.

After rough excavation, the surface is prepared for the application of asphalt by light dragging and rolling to obtain a relatively smooth surface in order to facilitate the laying of a uniformly thick and impermeable membrane. The rougher the sub-grade, the greater the quantity of asphalt required for satisfactory coverage.

- iii. The special asphalt used for the membrane is prepared by the catalytic blowing of asphaltic materials. It has a very low temperature susceptibility, a high degree of toughness, a resistance to tearing or breaking, and a long life. After the asphalt has been heated to approximately 400 °F, it is applied to the sub-grade under about 50 pounds pressure through spray nozzles, using either hand sprays or multiple spray bars mounted on the distributor. Holes or rough areas in the sub-grade can be adequately covered by the hand spray, though this method is somewhat slower. On the other hand, the distributor method is faster, and, therefore, more economical but can be applied satisfactorily only to reasonably smooth sub-grades.
- iv. The hot-applied asphalt cools quickly and is soon ready for the application of the cover material. In fact, a few minutes after the application, the surface may be walked over by the construction personnel in covering operations. Since the purpose of the cover material is to hold the membrane in its place, and to protect it from the sunlight, water, wave wash, or livestock damage the kind and depth of cover material depend on factors like wave-action, water turbulence and velocity. Where water velocities are below one foot and a half per second, the soil removed from the canal in over-excavation may be used provided it is of reasonable stability. If soil from canal excavation is not suitable, material with greater cohesiveness (clay contents) and stability may be borrowed. In canals with very high water velocities gravel blankets (usually of pit-run material) may be placed over the soil cover to depths between 3 and 6 inches. Riprap is often used for areas below check structures or where turbulence is severe. Compaction of the cover material is not ordinarily required but may be advisable in some instances. The life of an asphalt-membrane lining largely depends on the maintenance of the cover which is subject to beaching and weeds growth. (Beaching may be defined as the erosion of the canal bank at the water surface resulting primarily from wave-action.)

- v. The burlled asphalt membrane lining with cover operates essentially as an unlined canal, plans for the location and extent of such treatment can be altered on new construction without affecting the design of the canal or structures. Accordingly final decisions on these matters may be deferred till sub-grade conditions are exposed by excavation.
- vi. The membrane lining can be satisfactorily done both in cold and wet weather.

18.3 BRICK OR TILE LINING

The work to be done under brick or tile lining consist of constructing brick lining or tile lining according to the locations, dimensions and details shown on drawings or directed by Engineer-in-charge in accordance with these specifications and Engineer's instructions.

18.3.1 MATERIALS

All bricks or tiles, sand, cement and other materials required in constructing the brick or tile lining shall be furnished by the Contractor and be approved by the Engineer-in-Charge before use. Bricks, tiles, and mortar required in constructing the lining, and all operations of the Contractor in constructing brick lining, shall be in complete conformity with the applicable provisions set forth in the Section – 11 'Brickwork'.

18.3.2 FORMATION, DRESSING & PREPARATION OF SUB-GRADE

- i. The Contractor shall prepare the surfaces of the sub-grade in manner that will provide a smooth and firm foundation for the brick/tile lining. The bottom and side slopes, including the surfaces of compacted embankments, shall be finished accurately to the lines, grades and dimensions shown on the Drawings or established by the Engineer-in-Charge.
- ii. All excavation of the sub-grade beyond the lines of the underside of the brick lining shall be filled with suitable material, moistened if required, and thoroughly compacted to the prescribed lines and grades in accordance with the requirements of the Section-3 "Earthwork" or the Contractor may fill the over-excavated portion of the sub-grade with a mortar bedding consisting of one part Portland cement and six to ten parts sand, as approved by the Engineer-in-Charge.
- iii. The entire surface on which, brick-lining is to be placed shall be sprinkled with water till the optimum moisture content for compaction is attained as determined by the Engineer-in-charge or his authorized representative. It shall be compacted by rolling. Rolling shall be performed by using a smooth cylindrical roller. Two passes of the roller over the sub-grade shall be required.

Unless otherwise specified or directed by the Engineer-In-charge, the width of a roller drum shall not exceed 4 feet. The weight of the roller drum when fully loaded shall not be less than 50 pounds per linear inch of drum width. A roller may, consist of two adjacent drum units, provided that a flexible coupling between drums is used, and that the space between drums shall not exceed 12 inches. Single drum rollers shall overlap each roll by one half the width of the roller, and two drum rollers shall overlap each roll by one half width of the roller plus one foot. No earth filling shall be permitted after the rolling of the sub-grade, and over-excavated or low portion shall be filled with mortar at the expense of the Contractor.

- iv. After compaction the entire area to be brick lined shall be thoroughly sprinkled with water till the finished sub-grade has been penetrated to a depth of 6 inches. The water shall not be applied at the rate which will cause the sub-grade to be muddy or soft. The finished sub-grade shall be duly approved by the Engineer-In-charge or his authorized representative before any brick-lining is laid.

18.3.3 PROFILE WALL

Unless otherwise specified or directed in writing by the Engineer-In-charge, profile walls shall be constructed 15 feet centre to centre at right angle to the centre line of the channel on the side slopes and at 30 feet centers on the bed. A profile wall shall also be constructed

parallel to the centre line at each toe of the canal side slopes. The final excavation, trimming and compacting of the section may be performed before or after the completion of the walls.

The profile wall shall be laid by means of a theodolite. The excavation of trench in bed and on slopes for construction of profile including disposal of excavated material shall be made in accordance with applicable provisions of Section 3 – Earthwork.

A cement sand mortar as specified shall be laid as plaster over finally finished surface in accordance with applicable provisions of Clause 15.1.5 – Plastering. The wall shall be constructed in accordance with the Provisions of the Section 11 - Brickwork.

18.3.4 PLACING OF LINING

Unless otherwise specified, the placing of lining shall follow the sequence as given below:-

- i. A layer of 1:10 cement sand hand mixed mortar having an average thickness of $\frac{1}{2}$ inch shall be plastered over the finally finished sub-grade for making up inequalities in the section.
- ii. Immediately over it a $1\frac{1}{2}$ inches thick layer of 1:6 cement sand machine mixed mortar shall be laid. (The mortar used shall have a slump of $\frac{1}{2}$ inch to $\frac{3}{4}$ inch) To ensure that the correct thickness of $1\frac{1}{2}$ inches is laid over the whole surface, precast cubes 1:6 cement sand mortar having each side of $1\frac{1}{2}$ inches shall be placed on 1:10 plaster at 4 ft centre to centre along the centre line and at right angle to the channel and at 4 ft intervals. The cubes shall be left embedded in the mortar with their tops flush with the surface.
- iii. The 1:6 mortar layer shall be lightly rammed with wooden rammer and then trowelled to level out irregularities in the surface. The surface shall be rammed again with wooden rammer having $\frac{1}{2}$ inch long spikes with round ends to make indentations.
- iv. A $\frac{3}{8}$ inch thick layer of 1:3 cement sand machine mixed mortar shall be placed over the 1:6 cement sand base. (The mortar used shall have a slump of 2 inch). To ensure an even thickness, the 1:3 mortar shall be laid in strips 4 feet wide with the help of thin laths $1\frac{1}{2}$ " x $\frac{3}{8}$ " and about 18 feet long laid on the 1:6 cement sand base. The 1:3 mortar shall be spread with a trowel and leveled with a straight edge flush with the top of the lath. A day after the mortar is laid, it shall be lightly scraped with the wire brushes.
- v. The next and final layer shall consist of the brick/tiles. The courses shall be marked on the profile walls and the string shall be stretched to keep them straight. Brick tiles to be laid on slopes shall be laid from bottom to the top of side slopes. The laying of the brick/tiles shall commence from the profile wall at the tangent point. The bricks/tiles shall be laid in the 1:3 cement sand machine mixed mortar. The thickness of the mortar bedding under the bricks/tiles shall be $\frac{1}{8}$ of an inch and the vertical joints between the bricks/tiles shall be $\frac{1}{4}$ of an inch thick. All the joints shall be properly filled and to achieve this, the mason shall apply mortar to the sides of the bricks/tiles already laid, lay the next brick/tiles 1 inch to 2 inch away and then press it towards the first brick/tile squeezing out the mortar which would indicate that that joint has been filled. Before the bricks/tiles are laid they shall be soaked in water for at least 24 hours in soaking tanks. The mason shall have with him kerosene oil tin containing water, and the bricks/tiles from soaking tanks shall be placed in these tins. The mason shall use bricks/tiles only from these tins for his immediate requirements. Strict supervision shall be exercised to see that no un-burnt bricks/tiles are placed in the soaking tank and used.
- vi. The joints of the work done on the previous day shall be tested with a broad chisel pointed $\frac{5}{8}$ inch diameter iron bar. The hollow joints shall be marked with coal tar

raked out and filled with the 1:3 cement sand mortar immediately. The brickwork shall be finally brushed and cleaned.

18.3.5 CURING

Curing of each layer of the following work is necessary .

- a. Profile Wall
- b. Sub-grade 1-½ inch thick cement sand 1:10 mix
- c. Sub-grade 1-½ inch thick cement sand 1:6 mix
- d. Sub-grade 3/8 inch thick cement sand 1:3 mix.

During summer, curing shall be start three hours after the completion of each layer and during winter the very next day. Curing can be done by covering the sprinklers, porous hoses or pucca drains constructed along the top of the bank.

The overflow of water shall be affected by a man going along the drain and pushing water by a wooden rod, dipped in the drain: The watering of work shall be carried out on the following lines:

- i. Profile Walls:
A day after the walls are built, they shall be covered with jute cloth which is soaked by sprinkling water by hand, till curing can be started from the drain when ready.
- ii. Cement Sand Plaster 1: 10:
A day after the mortar is laid, it shall be kept wet by sprinkling water by hand, till it is covered by the 1:6 cement sand base.
- iii. Cement Sand Base 1:6:
A day after the 1:6 cement sand base is laid, the drain on its top shall be ready and the layer shall be kept thoroughly wet by overflow from this drain. Prior to the completion of the drain and putting it into operation the layer shall be kept wet by sprinkling water by hand.
- iv. Cement Sand Mortar 1:3:
A day after the 1:3 cement sand mortar is laid. It shall be kept soaking wet by water being made to overflow from the drain.
- v. Brick Masonry:
A day after the masonry is laid it shall be kept wet for 28 days by water being made to overflow from the drain.

18.4 CONCRETE LINING

The work to be done under concrete lining, consists of constructing concrete lining according to the detail and as per locations shown on the drawings or designated by Engineer-in-charge in accordance with these specifications and the Engineer-in-charge's instruction.

18.4.1 GENERAL

- i. Prior to the laying of concrete for canal lining: whether with Precast or cast in-situ Concrete, the Contractor shall ensure that the bottoms and sides of the excavated canal section are well compacted, trimmed and ready for the lining operation. In the event of failure to do so; any defects resulting in settlement, slips or bulges of concrete, the Contractor shall rectify the same at his own expense' by removing the concrete lining, compacting, trimming and re-lining the canal to the satisfaction of the Engineer-in-Charge.
- ii. Profiles and concrete lining shall be constructed to the best standards of workmanship obtainable, and any objectionable irregularities, fins and *offsets* in the lining shall be removed by the Contractor.

- iii. All bends in canal alignments shall be effected by means of smooth curves, the radius at the center-line of which shall not be less than twice the bed width of the canal.
- iv. The concrete for canal lining shall be unreinforced 1:3:6 (3000 psi 6 inch x 12 inch cylinder strength). Where in-situ concrete lining is shown in the contract Drawings to be reinforced, a layer of steel fabric reinforcement shall be laid prior to the placing of the concrete.

18.4.2 MATERIALS

- a. Sand, cement, coarse aggregates and water conforming with provision of Section-5 Plain and Reinforced Concrete required in constructing concrete lining shall be furnished by the Contractor and be approved by the Engineer-in-Charge.
- b. Cement, Sand and aggregate used in constructing the lining shall be furnished by the Contractor in accordance with the provisions of and complete conformity with the stipulations and requirements specified in the Section 5 – Plain & Reinforced Concrete. Bricks and mortar required in constructing the profile walls and all operations of the Contractor in constructing those shall be in complete conformity with the applicable provisions set forth in the Section 11 – Brickwork.

18.4.3 FORMATION, DRESSING & PREPARATION OF SUB-GRADE

i. Common Soils.

Although the same specifications and precautions shall apply as described in case of brick lining, however, the sub grade shall be compacted to 95% of Laboratory maximum dry density determined by Standard Proctor test or the 70% relative density depending upon type of material. The compacted Sections should extend not less than 2 feet below the final grade measured perpendicular to the surface of canal prism.

ii. Special Soils

In case of special soils, following further clauses shall apply;

a) PREDOMINANTLY SANDY REACHES

When canal is in cutting in predominantly sandy reaches compaction of subgrade shall be done as follows:

Consolidation of the bed shall be done by over-saturating the bed by flooding it with water before lining is laid; Consolidation of sides shall be done by over cutting the sub-grade by 6 inches and refilling it. With granular material stabilized with not less than 50% cement (measured by volume) and compacted by vibro-compaction.

b) EXPANSIVE SOILS.

When dry bulk density of natural soil is less than 1.89 kg/cm³ (68 lbs/in³) or the soil is of expansive nature, any of the practices detailed below shall be adopted (depending on swelling properties of the soil encountered).

If the expansive clay is in a thin layer or is in small pockets in an otherwise suitable sub grade, it shall be over excavated and replaced with a selected granular material properly compacted to a depth of 40 cm. If swelling of the clay encountered can be controlled by loading the surface with a non-expansive soil or gravel, the expansive clay bed shall be over excavated to depth of about 40 cm and filled to the grade of underside of the lining with good drainage material leading away the seepage water from the canal, to be released in to the canal again, through suitable pressure relief valves. The excavated surface of expansive clay shall be covered by polythene sheeting to prevent the entry of water into the clay.

c) SOILS WITH HIGH GYPSUM CONTENTS.

If Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is in high percentage in the soil and comes in contact with water, it dissolves causing cavities in the soil and damage to the structures by differential settlements.

Effective protective measures shall be taken to prevent gypsum coming in contact with water for making the concrete lining water proof, either by plastering the surface or placing a compacted layer of selected clay material under the lining or provide a flexible type membrane of Butyl or PVC etc,. Efficient drainage system may also be required to rapidly remove water that gets under the lining. The work shall be carried out as per the drawings and direction of the Engineer-in-Charge.

The Contractor shall rework the area which fail to meet specification requirement as above for common and special soils.

iii. **Tolerance limits of Sub-grade**

The previously compacted ground and embankments shall be trimmed within the following tolerances from given alignment.

- a) + 20 mm on straight sections.
- b) + 50 mm on tangents and partial curves.
- c) + 100 mm on 90 degree curves.
- d) + 20 mm from established grade.
- e) After trimming, the sub grade shall be kept moist by intermittent fine spraying with water, prior to the lining operation. The period between trimming and lining shall not exceed 72 hours.

iv. **Sub-grade Plaster**

Unless otherwise specified 13 mm thick plaster cement sand mix (1:10) shall be carried out on well prepared sub-grade. The plastered surfaces shall be subjected to curing with water for 24 hours before concrete lining is done. Sub grade preparation and the cement plastering above it shall be performed for enough length in advance, as directed by the Engineer-in-Charge, to avoid delay of the lining operations. The surface of sub grade shall be true to level and according to the specified cross section (of the canal) to form a firm compacted bed for lining, However, if at any point, material of sub grade has been excavated beyond the neat lines required to receive lining, the excess excavation shall be filled with material to be specified/directed by the Engineer-in-Charge to make it compatible with sub grade material and thoroughly compacted. After compaction, the entire area on which concrete lining is to be laid shall be thoroughly sprinkled with water till the finished sub grade has been penetrated to a depth of nearly 150 mm Then finished sub-grade shall be duly approved by the Engineer-in-Charge.

18.4.4 THE CONCRETE MIX.

The concrete in principle shall be produced in accordance with applicable provisions of Section 5, Plain & Reinforced Concrete.

The concrete mix shall conform to the mix design specified in the Drawings. Concrete used in Canal Lining, as a general principle, shall be so mixed that it is firm enough to stay in place on the side slopes. The net water-cement ratio of the concrete (exclusive of water within or absorbed by the aggregates) shall range from 0.53 to 0.58 based on the climatic temperature. Temperature of concrete when it is placed shall not be more than 32 degree C and not less than 5 degree C. Tests of the concrete shall be made by the Engineer-in-Charge, for the purpose of checking workability, density, impermeability, durability and strength. The Contractor shall maintain arrangements for testing of concrete.

Thickness

Unless otherwise specified, the thickness of concrete shall conform to the approved design/drawings.

18.4.5 PLACING CONCRETE

a) **General**

Before Commencement of Operations of Concrete Lining of Canal, the Contractor shall submit a complete method statement for performance of the work.

b) **Conventional Method**

- (i) Placing of concrete shall be started after all formwork, installation of parts to be embedded and preparation of surfaces upon which concrete is to be laid, have been completed. All absorptive surface against which concrete is to be laid shall be moistened thoroughly so that moisture shall not be withdrawn from freshly placed concrete, the surfaces, however shall be free from standing water and mud. The concrete shall unless otherwise approved by the Engineer-in-Charge be mixed in a mechanical mixer.

- (ii) Concrete shall be placed and properly compacted to the satisfaction of the Engineer-in-Charge. The arrangements are to be such that the material may be conveniently handled and placed in the required position without re-handling or segregation in panels of 3m on either side with joints at specified places in between. A slump of 6 cm to 7 cm shall be allowed. Wherever possible .the concrete is to be deposited from bottom-opening skips; it shall not be delivered by chute or dropped from burrows or otherwise through a greater height than 1.2 m, except with the approval of the Engineer-in-Charge who may order the concrete to be dropped on to a bunker and turned over by hand before being placed.

The lining shall normally be placed first on the bed and then on sides. Where site conditions require laying of lining on sides first, it shall be supported on toe walls. The concrete shall be dumped and spread on the sides and bottom of the channel in panels of not more than 3 m on either side with joints at specified places in between. Before laying the concrete. Precast or cast-in-situ, concrete bed sleepers shall be placed under the joints to serve as templates to reduce seepage through the joints and accurate dressing of the sub-grade. For placing of concrete on slopes, the use of a weighted vibrated steel faced slip.-form screed In the advancing direction of the concrete pour, shall be supported directly on the sub-grade and operated longitudinally along it. This method of placing shall generally be adopted for moderately large canals. For larger canals and for better economy, longitudinally operated slip forms supported on rails placed on berms of the canal shall be adopted.

- (iii) The surface on which concrete is to be deposited must be made and maintained free from standing water during concreting operations unless otherwise approved. Running water crossing or entering such areas must be brought under control to the satisfaction of the Engineer-in-Charge before concreting proceeds.
- (iv) All construction joints are to be shuttered square to the work. Keyways are to be formed in all horizontal and vertical construction joints except where ordered to be omitted by the Engineer-in-Charge.
- (v) All concreting shall be carried out in sections previously ordered or approved by the Engineer and shall proceed continuously in each section until completed and no interval shall be allowed to elapse while the work is in hand.

c) **Placing Machine Made In-situ Lining.**

For placing Machine Made In-situ Lining, the Contractor shall use a construction train for laying the concrete canal, lining which shall consist of mechanical trimmer: slip form paver

and platforms for lining construction, for cutting and filling contraction joints and for applying curing compound. All lining machinery shall have been built by a reputable manufacturer and evidence of satisfactory operation of similar equipment under similar conditions shall be provided.

While trimmers and slip form pavers are used, a qualified and experienced foreman provided by the manufacturer shall remain in attendance. The Engineer-in-Charge will not permit construction of lining to commence unless he is satisfied that there is a sufficiency of back up plant (e.g. concrete dump trucks) for the lining to progress without significant interruption.

It shall also be ensured that all the operators and mechanics are trained and experienced in such equipment's. Sample lengths of canal lining shall be constructed in advance so that the Engineer-in-Charge may consider and approve the method of working which the Contractor proposes to employ and the quality of lining to be achieved.

d) **Finishing**

Unless otherwise specified or as directed by the Engineer-in-Charge, the surface of concrete shall be finished smooth and free from projections, honey combing and other objectionable defects. All unsightly 'ridges or lips shall be removed and undesirable local bulging shall be remedied by tooling and rubbing. Repairs to concrete surfaces and additions, where required, shall be made by cutting regular openings into the concrete to the required lines. The fresh concrete shall be trowelled to the surface of the opening.

18.4.6 PRECAUTIONS

(i) **No Partially Set Material to be Used**

All concrete and mortar must be placed and compacted within 30 minutes of its being mixed unless otherwise approved; no partially set material shall be used in the work.

(ii) **Unsuitable Weather**

No concreting shall be allowed in the open during storms or rains. All concreting materials and plant are to be adequately protected against the effect of storms and rains.

All Concrete lining irrespective of whether pre cast or cast-in-situ, shall be laid in the dry. The Contractor shall provide sufficient pumping equipment to ensure that any dewatering that is required is effectively carried out.

18.4.7 CURING AND PROTECTION.

(i) The concrete shall be covered with hessian and kept watered and continuously damp for a minimum of three days after placing or for such time as the Engineer-in-Charge may direct. Other methods of preventing the water of hydration in the concrete from evaporating may be used with the approval of the Engineer-in-Charge. After a period of 24 to 36 hours, the lining shall be cured for at least 28 days. On bed this shall be done by constructing 15 cm deep earthen bunds across the bed so that a small depth of water shall stand on the bed. The curing of side slopes shall be done by constructing masonry drains on the berms with weep holes or perforated pipes installed on the berms or by sprinklers. Curing compound SIKA or equivalent may be used if specified.

(ii) Concrete shall be protected wherever practicable from the direct rays of the sun during the curing period.

(iii) Precast concrete slabs used for canal lining shall be cast to the dimensions as shown in the Drawings. They shall be laid square, in straight lines and in a workmanlike manner, and shall be pointed or grouted with 1:2 cement -sand

mortar. Laying of the slabs shall commence from the bed. working up the slopes. Wavy, crooked or irregularly laid slabs will not. be accepted and the Contractor shall at his own expense remove and rectify the same to the satisfaction of the Engineer-in-Charge. The Contractor shall exercise all care and diligence in the handling of the concrete slabs. Broken and irregularly shaped slabs shall be rejected and removed forthwith from the site by the Contractor.

18.4.8 JOINTS

- (i) Contraction joints, where specified shall be formed as deliberate planes of discontinuity in the concrete structure as opposed to construction joints where continuity has to be maintained. A Construction joint shall consist of saw cut 7 mm in width and (1/6th the thickness of Concrete in depth. Alternatively to form such a joint the face of concrete slab or block first formed shall be painted with two coats of approved rubber bitumen paint before the adjoining slab or block is concreted.
- (ii) Expansion joints as detailed in the Contract drawing shall be formed in the same way as construction joints. Generally, these shall be 13 mm wide; 102 mm to 152 mm deep. Either an approved' compressible sheet or filler shall be supplied and placed in the joint to provide freedom for two adjacent concrete slabs / blocks to expand or the joint shall be filled with bitumen, sand & saw dust in the ratio of 1 :2:2 and shall extend to full depth of lining. In certain specified situations a highly compressible joint filler of foam rubber or other approved material shall be used. The exposed edges of the joint shall be sealed with an approved synthetic rubber or similar resilient sealing compound.

18.4.9 UNDER-DRAINAGE/ PRESSURE RELIEF VALVES.

In stretches of concrete lined canals where a buildup of hydrostatic pressure is expected behind the concrete lining, thereby endangering their stability, the Contractor shall supply and fix pressure relief valves on the bed of the canals together with the appropriate graded filter material as shown in the Drawings. The Contractor shall be responsible for obtaining particulars of locations of pressure relief valves from the Engineer-in-Charge prior to the laying of the concrete lining. The provision of relief valves shall be associated with construction of the proper grading and laying of the filter material as specified to ensure proper and effective performance of the relief valves. Any relief valve rendered ineffective as a result of the Contractor's negligence and improper grading and laying of the filter material shall be removed and made good at the Contractor's own expense.

18.5 MEASUREMENT AND PAYMENT

18.5.1 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.

18.5.2 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.

18.5.3 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.: 18-12 to 18-17
2. For surface area items, the quantity of work shall be measured by surface area. The unit of measurement shall be Square meter or Square foot. Following items of CSR are measured according to this criteria;
Item No.: 18-1 to 18-11