



Government of Nepal  
Ministry of Energy, Water Resources and Irrigation  
Department of Water Resources and Irrigation

**STANDARD SPECIFICATIONS**  
**FOR**  
**IRRIGATION AND RIVER TRAINING**  
**WORKS**

**2081**

## SECTION 200: SITE PREPARATION

### 201 CLEARING AND GRUBBING

#### (1) Scope

The Section covers the clearing and grubbing necessary for the construction of the works covered by the contract. Conservation of the top soil and flora is also covered under this Section.

#### (2) Description of Work

##### (a) Clearing

Clearing shall consist of the cutting, removing and disposal of all tree, bushes, shrubs, grass, weeds, other vegetation, anthills, rubbish, fences, top organic soil not exceeding 150 mm in thickness and all other objectionable material, resulting from the clearing and grubbing. It shall also include the removal and disposal of structures that obtrude, encroach upon or otherwise obstruct the work.

The moving of a certain amount of soil or gravel material may be inherent to or unavoidable during the process of clearing and no extra payment shall be made for this. Clearing shall include the removal of all rocks and boulders of up to 0.15 m<sup>3</sup> in size exposed or lying on the surface.

##### (b) Grubbing

In the canal way all trees up to 300 mm girth, stumps and roots shall be removed to a depth of not less than 500 mm below the original ground level and a minimum of 700 mm below the original ground level.

Except in borrow areas the cavities resulting from the grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

##### (c) Conservation of Top Soil

Where suitable top soil exists within the limits of the area to be cleared and grubbed, the Contractor shall, if ordered by the Engineer, remove the top soil together with any grass and other suitable vegetation. If not used immediately, the top soil shall be transported and deposited in stockpiles for later use.

##### (d) Conservation of Flora

Where provided for in the contract, certain designated flora encountered in the canal reserve and borrow areas shall be carefully protected by the Contractor. In his tendered rate for Site Clearance, he shall include for the careful removal and planting of the flora in a protected and fenced-off area and, on completion of the canal, for there planting of the flora in suitable positions in the canal reserve in accordance with the Engineer's instructions.



**(3) Execution of Work**

**(a) Areas to be Cleared and Grubbed**

Stumps, embedded logs, roots and all other vegetation growth and accumulated rubbish of whatsoever nature and all other objectionable material shall be completely removed to adept has specified in Sub-clause 201 (2) (a) and (b).

Normally the portions of the canal reserve that fall within the limits of the canal prism, as well as certain borrow areas shall be cleared and/or grubbed. The full width of the canal reserve shall be cleared and/or grubbed except for such trees designated by the Engineer to be left standing and uninjured.

The Contractor shall mark the boundaries of the area for clearing and grubbing and seek the approval of the Engineer before commencement of the work. The Engineer shall designate in detail the exact areas to be cleared, and grubbed and the time at which it shall be done.

**(b) Cutting of Trees**

The Contractor shall take the necessary precautions not to damage to structures and other private or public property. If necessary, trees shall be cut in sections from the top downwards. The branches of trees to be left standing shall be trimmed so as not to intrude the carriage way of the canal.

Such individual trees as the Engineer may designate and mark in white paint shall be left standing and uninjured. In order to minimize damage to trees that are to be left standing, trees shall be felled towards the center of the areas being cleared, if so required by the Engineer.

Permission for cutting trees must be obtained from the competent authority who may require that trees be numbered, measured and marked in the presence of officials from that authority. Cutting of such trees shall then be carried out by the Contractor and the timber stored at designated locations.

Felling and cutting of trees on the site and pilling them off the site shall conform to the requirements of the competent authority.

All tree trunks and branches in excess of 150 mm in diameter shall be cleaned off, secondary branches cut into suitable length and stacked at sites indicated by the Engineer. Such timber shall not be used by the Contractor for any purpose and shall remain the property of the Employer.

All timber except such timber as can be used and all brush, stumps, roots, rotten wood and other refuse from the clearing and grubbing operations shall be completely removed from within the occupied space of Canal.

**(c) Dealing with Anthills**

Where anthills are encountered within the limits of the canal way, they shall be excavated to a depth of not less than 500 mm below the original ground level and the

  
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material carted to spoil. Cavities resulting from the clearance of anthill material shall be backfilled as required with approved material and compacted to a density not less than that of the surrounding ground.

Where directed by the Engineer, the area covered by anthills shall be treated, after excavation and before backfilling of cavities, with an approved ant control chemical. Payment for such treatment shall be made in the manner specified in the contract.

### (d) Disposal of Material

Material obtained from clearing and grubbing shall be disposed off in borrow pits or other suitable places and be covered up with soil or gravel as directed by the Engineer. The burning of combustible material shall not, normally, be permitted and may only be done with the prior written approval of the Engineer.

Where fences have to be taken down, fencing wire shall be neatly wound into reels and all such wire, together with all fence posts and other serviceable material from structures, etc., shall be stacked at sites indicated by the Engineer.

### (e) Reclearing of Vegetation

When portions of the canal reserve, borrow or other areas have been cleared in accordance with the Specifications, but in the course of time, vegetation grows again during construction, the Engineer may, if he considers it necessary, order that the area be recleared.

Before the bottom layer of the embankment is made, the Contractor shall grub up and remove any vegetation that may in the meantime have grown on the surfaces previously cleared and grubbed.

Such re clearing of areas previously cleared include the removal and disposal of grass, shrubs and other vegetation in the same manner as for the first cleaning operation. No separate payment shall be made for reclearing of vegetation.

## (4) Measurement

Clearing and grubbing executed as per this Specification shall be measured in square meter.

Cutting trees including removal of stumps and their roots of girth from 120 mm and backfilling to required compaction shall be measured in number according to the sizes given below:

- (a) 120 mm to 300 mm
- (b) Above 300 mm to 600 mm
- (c) Above 600 mm to 900 mm
- (d) Above 900 mm to 1200 mm
- (e) Above 1200 mm to 1800 mm
- (f) Above 1800 mm to 2400 mm
- (g) Above 2400 mm to 3000 mm
- (h) Above 3000 mm

For this purpose, girth shall be measured at a height 1 meter above the ground. Cutting of trees up to 120 mm girth including removal of stumps and roots and backfilling of holes with compaction shall not be measure separately.

  
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**(5) Payment**

Clearing and grubbing and cutting trees shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112. The contract unit rate for cutting of trees of girth 120 mm shall also include handling, salvaging, piling and disposing off the cleared materials with all leads and lifts.

**202 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES**

**(1) Scope**

This work shall consist of removing as here in after set forth existing culverts, bridges, aqueducts, syphons, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, buildings etc., which are in place but interfere with the new construction or are not suitable to remain in place, and salvaging and disposing off the resulting materials and back filling the resulting trenches and pits as required.

**(2) General**

- (a) Only those structures designated by the Engineer, or shown on the Drawings, shall be demolished or removed.
- (b) Dismantling and removal operations shall be carried out in such a way that the adjacent structures beyond the canal right of way are left intact and in place. All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to start of new work.
- (c) Existing culverts, bridges, buildings and other structures which are within the canal way and which are designated for removal, shall be removed up to the limits and extent specified on the Drawing or as indicated by the Engineer.
- (d) Materials that are to be salvaged shall be carefully removed and stockpiled near the site at a location designated by the Engineer. The cost of Materials which are to be salvaged or used in the reconstruction work, if found damaged or destroyed as a result of the Contractor's operations, shall be borne by the Contractor. Materials that are not to be salvaged and stockpiled, shall be removed and disposed away from the site by the contract or at his own expenses. Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of all adhering material before being embedded in new concrete.
- (e) When pipe culverts, wooden culverts, gabion walls or other structures with a salvaged value are removed, care shall be exercised in their safe removal. The material involved shall be kept intact without damage. The Contractor shall be responsible for the satisfactory removal of such structures in a usable condition.
- (f) Salvaged reinforced concrete pipes, corrugated steel pipes, wooden boxes or other structures shall be stored at places as directed by the Engineer or shown on the Drawing. Structures or portions there of which are specified in the contract for erection shall be stored in separate piles.



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- (g) Timber or lumber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed there from and shall be stored in neat piles in locations suitable for loading.
- (h) All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.
- (i) All salvaged materials shall be the property of the Employer.
- (j) All materials obtained from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed off.

### (3) Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the materials shall be so removed as not to cause any damage to the serviceable materials to be salvaged. The part of the structure to be retained and other structures nearby shall be safeguarded against any damages.

Where existing culverts/bridges are to be otherwise incorporated in the new work, only such parts of the existing structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connection edges shall be cut, chipped and trimmed to the required lines and grades without tweekening or damaging any part of the structure to be retained.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. The structure shall be removed in a condition suitable for re-erection unless otherwise shown on the Drawing. All members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pinholes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

### (4) Dismantling Other Structures

In removing pavements, kerbs, gutters, walls and structures like catch pits, outlets, etc., where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with face perpendicular to the surface of existing structure. All other structures designated for removal shall be brokento pieces whose volume shall not exceed 0.02 cubic meters and stockpiled at designated locations if the materials are to be used later or otherwise arranged for disposal.

### (5) Back-filling

Holes and depressions caused by dismantling operations shall be backfilled as required with excavated or other approved materials and compacted to required density as directedby the Engineer.

### (6) Measurement

Prior to commencement of dismantling, the work of dismantling structures shall be measured in the units given below:

SN	Type of Work	Unit
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(i)	Dismantling brick/stone masonry/Concrete(plan and reinforced)	cu.m.
(ii)	Dismantling gabion	cu.m.
(iii)	Dismantling steel structures	ton
(iv)	Dismantling timber structures	cu.m.
(v)	Dismantling pipes, guard rails, Kerb sand gutters	lin. m.
(vi)	Utility services (Telephone Lines, Electric Lines)	lump sum
(vii)	Pavement	cu.m.
(viii)	Dismantling pipe culverts	no.
(ix)	Dismantling pitching and ripraps	sq. m.

Associated works like disposal, stockpiling, marking and numbering, etc., shall not be measured separately.

**(7) Payment**

The various dismantling works shall be paid at their respective contract unit rates which shall be full and the final compensation to the Contractor as per Clause 112 and for the cost of all operations involved for completion of this item.

  
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## SECTION 300: EARTHWORKS

### 301 SCOPE

This Section covers the works related to the canal excavation, filling for canal banks and embankments, excavation for foundation, backfilling, excavation for drains, channels etc.

### 302 DEFINITIONS AND GENERAL REQUIREMENTS

- (1) Earthwork includes two types of operations i.e. (i) earth excavation and disposal of the excavated materials (ii) earth excavation and use of excavated materials. The use of excavated material may be in the form of filling embankment, backfilling, filling other areas as required.

Earth excavation and disposal implies excavation of all types of materials including part of the structures below ground level within and outside of the limit of the right of way of canal except for otherwise specified, shaping the exposed surface of excavation as specified or directed by the Engineer, removal, hauling and disposal of the excavated material at the locations and in the manner as specified or directed by the Engineer.

Excavation and filling implies excavation of materials and shaping the exposed surface of excavated as stated, removal hauling and use of the excavated material at the location and in the manner as specified or directed by the Engineer.

Excavation and disposal shall include:

- (i) Excavation and disposal of any type of material included on the Drawing.
- (ii) The excavation and disposal of existing surfacing.
- (iii) Excavation and disposal of slides, breakages and caving-ins.
- (iv) Excavation and disposal for stream channel, trenches and drains etc.
- (v) Excavation required in cuts or under embankments below the lowest normal limit of excavation as indicated on the Drawing or below ground line.
- (vi) Excavation and disposal of unsuitable materials.
- (vii) Removal or partial removal of existing embankments and disposal of the materials as shown on the Drawing or as directed by the Engineer.
- (viii) Excavation for foundation and disposal of materials.

Excavation and filling shall include:

- (i) Filling for embankment
- (ii) Filling for guide bunds, coffer dams, etc.
- (iii) Backfilling in trenches, foundation pits etc.
- (iv) Any type of other filling or backfilling whereby the ground level is raised or a hole is filled up.

- (2) The following definitions of earthworks materials shall apply to this and other Clauses of these specifications, if otherwise not specified.

- (i) "Topsoil" shall mean the top layer of soil that can support vegetation. It shall include all turf acceptable for turfing.
- (ii) "Suitable Material" shall comprise all that is acceptable in the accordance with the Contract for use in the Works and which is capable of being compacted in

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the manner specified in Clause 309 and 310 to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except for rock fill) shall not contain rock fragments with dimensions of more than 75 mm.

(iii) "Unsuitable Material" which cannot be considered suitable for embankment shall mean other than suitable material and shall include:

- (a) Material from swamp, marshes or bogs;
- (b) Peat, logs, stumps, perishable material, organic clays;
- (c) Material susceptible to spontaneous combustion;
- (d) Material in a frozen condition;
- (e) Clay of liquid limit exceeding 50 and/or plasticity index exceeding 25;
- (f) Dispersive soil (Soil with predominance of sodium cations) ;

Material stated above in (d) if otherwise suitable shall be classified suitable when unfrozen.

(iv) "Unsuitable Material" which cannot be considered suitable for construction of irrigation/drainage canal shall mean other than suitable material and shall include:

- (a) Dispersive soil (Soil with predominance of sodium cations) ;

(v) "Rock Fill" shall consist of hard material of suitable size for deposition and compaction as given in Clause 309 and also may comprise rock as defined in Clause 303 and broken stones.

(vi) "Well Graded Granular Material" consists of gravel and/or sand conforming to relate IS Codes.

(3) No excavated suitable material other than surplus to requirements of the contract shall be removed from the site except on the direction of the Engineer. Should the Contractor be permitted to remove suitable material from Site to suit his operational procedure, then he shall make good at this own expense any consequent deficit of filling arising therefrom.

(4) Material in surplus to the total requirements of works, and all unsuitable material shall, unless the Engineer permits otherwise, be run to spoil dumps.

(5) Where the excavation reveals a combination of suitable and unsuitable materials the Contractor shall carry out the excavation in such a manner that the suitable materials are excavated separately for use in the works without contamination by the unsuitable materials.

(6) The Contractor shall make his own arrangements for the stockpiling of top-soil and/or suitable material.

(7) At all times the Contractor shall ensure that earthworks are not damaged by weather or traffic. In event of such damage, the Engineer may withdraw approval from the affected works until the Contractor has carried out repairs to restore the works to their original condition.

The cost of all such repairs and any additional testing shall be borne by the Contractor.

(8) Prior to commencement of any earthwork, the work shall be set out where required as specified in Clause 104 following the clearing and grubbing as per Section 200 and Survey of the existing ground shall be conducted jointly by the Contractor and the



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Engineer. The survey records shall serve as initial measurements for the determination of the final quantities of earthwork performed under the contract.

- (9) Works on embankments and/or cutting in areas required for the construction of bridges and other structures shall not be carried out until the Engineer agrees that construction of such structures is sufficiently advanced that there is no interference or damage to them.
- (10) The Contractor shall get approval of the Engineer in respect of method of earthwork, type of equipment to be used, disposal and other details before commencement of the earthwork.

### 303 CLASSIFICATION OF EXCAVATED MATERIALS

The excavated materials shall be classified under the following categories. The decision of the Engineer in respect of the classification of excavated materials shall be the final and binding upon the Contractor.

**Classification:** All materials involved in excavation shall be classified by the Engineer in the following manner:

#### (1) Soil

This shall comprise topsoil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having dimension in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

#### (2) Gravel Boulder Mixed Soil (GBM Soil)

Gravel Boulder Mixed (GBM) soil refers to a type of soil composition that contains a mixture of gravel, cobbles, and other materials. It is a coarse-grained soil type that typically has a higher percentage of larger particles such as gravel and cobbles compared to finer particles like sand or silt. GBM soil is commonly found in areas with rocky or mountainous terrains where weathering and erosion have led to the accumulation of large-sized particles. It is often challenging to work with GBM soil due to its coarse nature, which can affect construction as well as excavation activities. This shall comprise topsoil mixed with gravel less than 75mm and cobbles not more than 300 mm and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other digging equipment (Cobbles pass a 300-mm equal to 12-inch square opening but are retained on a 75-mm sieve whereas boulders are too large to pass a 300-mm square opening).

#### (3) Dispersive Clay

Dispersive soil refers to a type of soil composition that have a preponderance of sodium cations. This soil is not suitable for construction of canal in cutting or in embankment and for construction of any type of hydraulic structures. Dispersive clay soil erodes in the presence of flowing water when individual clay platelets are split off and carried away. The hydraulic structures including irrigation/drainage canal

  
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constructed in dispersive soil fail by piping. Using dispersive clay soils in irrigation/drainage canal construction, hydraulic structures, embankment, dams, or other structures such as roadway embankments can cause serious engineering problems if these soils are not identified and used appropriately with due treatment. Problem due to dispersive soil is worldwide, and structural failures attributed to dispersive soils have occurred in many countries. The principal difference between dispersive clays and ordinary erosion resistant clays appears to be the nature of the cations in the pore water of the clay mass. Dispersive soil have predominance of sodium cations whereas ordinary clays have a preponderance of calcium, potassium, and magnesium cations in the pore water. Dispersive clays have not been definitively associated with any specific geologic origin but most have been found as alluvial clays in the form of slope wash, lake bed deposits, loess deposits, and flood plain deposits. Dispersive clay soils, which are available in red, brown, gray, yellow, or various combinations of these colors look like ordinary clay and hence cannot be distinguished by naked eyes. Dispersive clays cannot be identified by the standard laboratory index tests such as visual classification, grain size analysis, specific gravity, or Atterberg's limits either and, therefore, other laboratory tests such as the crumb test, the double hydrometer test, the pinhole test and chemical test have been devised for this purpose.

### (4) Ordinary Rock (not requiring blasting)

This shall include:

- (i) rock types such as laterites, shales and conglomerates, varieties of limestone and sandstone etc., which may be quarried or split with crow bars, also including any rock which in dry state may be hard, requiring blasting but which, when wet, becomes soft and manageable by means other than blasting; macadam surface such as water bound and bitumen/tar bound; soling of roads, paths etc. and hard core; compact moorum or stabilized soil requiring grafting tool or pick or both and shovel, closely applied; gravel and cobble stone having maximum dimension in any one direction between 75 and 300 mm; lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar below ground level, reinforced cement concrete which may be broken up with crow bars or picks and stone masonry in cement mortar below ground level; and boulders which do not require blasting having maximum dimension in any direction of more than 300mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.

### (5) Hard Rock (requiring blasting)

This shall comprise:

- (i) any rock or cement concrete for the excavation of which the use of mechanical plant and/or blasting is required;
- (ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
- (iii) Boulders requiring blasting.

### (6) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (c) but where blasting is prohibited



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for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

### (7) **Marshy Soil**

This shall include soils like soft clays and peats excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

### (8) **Authority for classification:**

The classification of excavation shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Engineer.

## 304 **EXPLOSIVES AND BLASTING**

### (1) **General**

The procurement, transportation, storage, use, account and disposal of balance and defective explosive materials shall be strictly as per prevalent laws and ordinances applicable to the work site. Should there be any discrepancy found between procedures described hereunder and the prevalent laws and ordinance, the later shall supersede.

Blasting shall be carried out in a manner that completes the excavation to the

Lines indicated on the Drawing or as directed by the Engineer, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer.

The Contractor shall adopt such method that is consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

### (2) **Material, Tools and Equipment**

All the material, tools and equipment used for blasting operations shall be off approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be water-resistant and shall remain unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as shall permit sufficient time to the firer to reach to a safe place before explosion takes place. Detonators shall be capable for giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use. The damaged articles, if any, shall be discarded totally and removed from the site immediately.

### (3) **Personnel**

The blasting operation shall remain in the charge of competent and experienced blaster with legal license and thorough knowledge of handling explosives and blasting operations.

### (4) **Blasting Operations**

Explosives shall be used in the quantities and manner recommended by the

  
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manufactures. The written permission of the Engineer shall be obtained for each location or series of locations where the Contractor wishes to use more than 5 kg of explosives in one series of blast. Such permission shall not in any way relieve the Contractor of his liabilities under the Conditions of Contract.

The blasting shall be carried out during fixed hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the blaster only.

The Engineer must be notified at least 24 hours in advance on any blasting operation. When blasting is to be carried out, the Contractor shall determine the danger zone likely to be created, and shall ensure that all personnel, vehicles and livestock are clear of the zone before and during the blast. In settled areas, the Contractor shall take steps to avoid damage to property from flying rock by using blasting mats or other suitable blanketing materials.

The Contractor shall notify each public utility organization/company having structures in proximity to the site of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury.

Danger red flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded from the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose.

The charge holes shall be drilled to required depths and at suitable places. Blasting shall be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued. Not more than 10 charges shall be prepared and fired at a time. The man in charge shall blow a siren in a recognized manner for cautioning the people. The charges shall be lighted by the blasters only. The blaster shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

After blasting operations, the Contractor shall compact the loose residual material removed below sub-grade and replace the material removed below sub-grade with suitable material.

When forming final cut faces, pre-split blasting techniques as recommended in the Specification for Road and Bridge (IRC) shall be carried out to ensure that blasting damaged to the cut face is minimized. Details of the pre-splitting technique to be used shall be notified to and approved by the Engineer at least 24 hours in advance of the blasting operation.

### (5) Misfire

In case of misfire, the following procedure shall be observed:

(a) Sufficient time shall be allowed to account for the delayed blast. The blaster shall



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inspect all the charges and determine the missed charge.

- (b) If it is blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.
- (c) In case of charges of gelignite, the blaster shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 30 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired hole should explode at the same time. The blaster shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.
- (d) If a misfire had been found to be due to defective detonator or gelignite/dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority as directed by the Engineer for inspection to ascertain whether all or part of the remaining materials in the box are also defective.

### (6) Account

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times. Records must be kept by the Contractor of all drilling and blasting operations showing holes diameters and depths, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Engineer on completion of charging.

## 305 EXCAVATION IN CUTTING

- (1) Cleaning and grubbing shall be performed as specified in Section 200.
- (2) While executing excavations, the Contractor shall take adequate precautions against soil erosion and water pollution.
- (3) All suitable excavated materials shall be used in construction of the canal banks/embankment to the extent as required.
- (4) Hauling of material from cutting or borrow pits to embankments other areas of fill shall proceed only when plant or labour is operating at the place of deposition to ensure that adequate spreading and compaction of material can take place.
- (5) Over-excavation shall not be permitted. Any excess depth excavated below the formation levels as specified shall be made good by the Contractor at his own expense by backfilling with suitable material of similar characteristics to those of moved materials with compaction as specified in Clauses 309 and 310.
- (6) The slopes of cutting shall be cleared of all rock fragments which move when prized

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by a crowbar, unless otherwise directed by the Engineer. Where the Engineer considers that the slope, immediately after dressing, shall not be permanently stable, he shall direct the Contractor as to the stabilization measures required. The Contractor shall carry out these measures soon after Engineer's instruction.

When completed, the excavation slopes shall be true to the lines and levels as shown on the Drawing or directed by the Engineer. When completed, no point on slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock, no point shall vary more than 300 mm from the designated slope.

- (7) If slips, slides, over breaks or subsidence occur in cutting, they shall be removed. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.
- (8) If water is encountered in excavations due to seepage, springs, or other causes such as marshy soil, it shall be removed by suitable diversions or bailing out and the excavation shall be kept dry. The drained water shall be discharged into suitable outlets as not to damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.
- (9) Stones encountered during excavation/cutting of soil shall be removed and disposed as directed by Engineer. Removal of stone and their subsequent disposal shall be treated as separate item if mentioned in the BoQ, and shall be paid at unit rate provided in the BoQ.

### 306 EXCAVATION BELOW EMBANKMENTS

- (1) Where any unsuitable material below the natural ground level under proposed embankments is required to be excavated, it shall be removed to such depth and over such areas as shown on the Drawing or as directed by the Engineer. The excavated materials shall be disposed off as indicated on the Drawing or directed by the Engineer. The resultant excavation shall be backfilled with suitable material and shall be levelled and compacted to the density as specified for forming of the embankments.

Nevertheless, if such backfill has to be carried out in standing water, the Contractor shall use only an approved non-plastic well-graded granular material having maximum size of not greater than 75 mm. Such materials may be deposited in water without use of compaction equipment.

- (2) Where shown on the Drawing, approved, graded stones having size from 380 mm to 150 mm and containing not more than 10 percent, below 150 mm in size shall be placed directly on the natural occurring unsuitable material. This type of rock fill material shall be deposited in accordance with the requirements of Clause 309 and compacted as per Clause 310.
- (3) If after the removal of material as specified in Sub-clause 306 (1), the Contractor allows the materials so exposed to reach a condition where compaction of back filling is impracticable, he shall make good at his own expense either by additional

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excavation and filling in the manner specified in this Clause, or by waiting until the condition of the exposed material is fit to receive the approved backfill.

**307 EXCAVATION FOR FOUNDATION**

**(1) Slope**

Excavation shall consist of the removal of material for the construction of foundations for drainage structures, retaining walls, head walls, cut off walls, culvert, bridges and other similar structures to the lines and dimensions shown on the Drawing or as instructed by the Engineer in accordance with the requirements of these specifications. The work shall include construction of the necessary cofferdams and cribs and subsequent removal of all necessary sheeting, shoring, bracing, diversion of water/flow, draining and pumping, the removal of all logs, stumps, grubs and other deleterious matters and obstructions necessary for placing the foundation; trimming bottoms of excavations; and cleaning up the site and the disposal of all surplus material.

**(2) Excavation**

Excavation shall be taken to the length and width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench does not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The depth to which the excavation is to be carried out shall be as shown on the Drawing or as directed by the Engineer.

Where blasting is to be restored to, the same shall be carried out in accordance with Clause 304.

**(3) Dewatering, Diversion of Flow and Protection**

Normally, open foundation shall be laid dry. Where water is encountered in excavation due to stream flow, seepage, spring, rain or other reasons, the Contractor shall take adequate measure such as bailing, pumping, constructing diversion channels, drainage channels, bunds, cofferdams and other necessary works to keep the foundation pit or trenches dry, when so required and to protect the green concrete/masonry against damage by erosion, failure of cut slope or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor, but subject to approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Where cofferdams are required, these shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for

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facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipment, etc., inside the enclosed area.

Cofferdam sheet-piling shall be carried down well below the bottom of the pile caps or footings, but without interference with any bearing piles. Cofferdams shall be rigidly constructed and efficiently braced to withstand external pressures when water is pumped out. Sheeting shall be reasonably watertight and all appreciable leaks encountered during the operations shall be stopped so that construction of pile caps can be carried out in the dry. The Contractor shall rectify any cofferdam which, for any reason, has moved, tilted, or changed its shape and/or size.

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

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the area of excavation.

The Contractor shall take all precautions in diverting flow and in discharging the drained water as not to cause damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original at his own cost or compensate for the damage.

### (4) Preparation of Foundation Base

The bottom of the foundation pit shall be levelled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed, if surface is not wet. In the event of excavation having been made deeper than that shown on the Drawing or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation grade at the cost of the Contractor. Ordinary filling shall not be allowed for the purpose to bring the foundation to level. When rock or other hard strata is encountered, it shall be freed of all soft and loose materials, cleaned and cut to firm surface either levelled or stepped as directed by the Engineer. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the Engineer. In the case of rock excavation, annular space around footing shall be filled with concrete of grade M 10 up to top level of rock.

After the excavation is completed, the Contractor shall inform the Engineer to that effect and no footing, bedding materials or structures shall be placed until the Engineer has approved the depth and the suitability of foundation material.

If, at any point, in any foundation excavation, material unsuitable for foundations is encountered, the Contractor shall, if so instructed by the Engineer, shall remove all such materials and refill with suitable materials thoroughly compacted by tamping or rolling in layers of not more than 150mm thick each.

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**(5) Slips and Blows**

If there are any slips or blows in the excavation, these shall be removed by the Contractor at his own cost.

**(6) Public Safety**

Where required, trenches and foundations pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accident as per Sub-clause 102 (5).

The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures.

**(7) Removal of Cofferdams**

All cofferdams with all temporary sheeting and bracing shall be removed by the Contractor after the completion of the substructure unit. The removal shall be carried out in such a manner as not to disturb or damage the finished concrete. However, sheet piling below the top of the pile caps may be left in place at the Contractor's option and expenses.

No bracing no other material shall be left in cofferdam in such a way as to extend into the concrete of the structure.

Cofferdams located in a stream or lake and within the limits of low water shall be removed to the elevation of the stream or lake bed, except that in established navigation channels, they shall be removed to an elevation at least 600 mm below the established bottom of the channel.

**308 REFILLING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLING TO STRUCTURES**

Refilling of foundation pits and trenches shall consist of previous backfill and/or common backfill as shown on the Drawing or as directed by the Engineer.

**(1) Materials**

**(a) Pervious Backfill**

Unless otherwise specified in the contract, it shall be of gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof. It shall conform to the grading limits set out in Table 3.1.

**Table 3.1: Grading Limits of Pervious Backfill**

Sieve Size (mm)	Percentage Passing by Weight
40	100
10	45-100
2.36	25-80
0.60	8-48
0.075	0-6

**(b) Common Backfill**

Common backfill materials other than pervious backfill shall be suitable material as defined in Sub-clause 302 (2).

**(2) Method of Filling**

Backfilling material shall be placed and compacted in layers in compliance with the requirements of Clause 310. Any support structures for the excavation shall be withdrawn as the filling proceeds unless described in the contract or ordered by the Engineer to be left in. The backfill shall be placed in by such methods which shall avoid loading the structure in any manner which may affect its stability or overload its underlying foundation material or substructure. The backfill in front of abutments and wing walls shall be placed first to avoid the Possibility of forward movement. Precautions shall be taken to prevent any wedge action against upright surfaces, and the slopes bounding the excavation shall be stepped as directed by the Engineer before backfill is placed. The backfill material around box culverts, piers and curtain walls shall be placed simultaneously on both sides of the structure. When the structure is so designed that its strength is dependent on the restraining effect of the superstructure (such as in portal frames and propped abutments), the backfill shall not be placed until the superstructure has been completed to the extent and strength necessary to provide the required restraint. When the Contract requires wedges between steel superstructure and the parapet of wing type abutments, the wedges shall be placed in advance of placing any fill above the lower 1/3 of the abutment and shall be removed when directed by the Engineer.

**309 FORMING OF EMBANKMENT AND OTHERS AREAS OF FILL**

- (1) The work shall consist of the construction of embankment, filling on other areas and backfill not specified elsewhere by providing material as specified or approved by the Engineer, placing, compacting and shaping to lines, levels, grades and cross sections as shown on the Drawing or as directed by the Engineer. The maximum size of the coarse material in the mixture shall not exceed 75 mm for general earth fill.
- (2) The limits of embankment shall be built sufficiently wider than the design dimension to facilitate in achieving required compaction nearby outer faces of the embankment. The surplus material shall be trimmed to conform the specified side slopes and width of the embankment.
- (3) Where necessary, the original ground shall be scarified, mixed with water, levelled and then compacted so as to achieve the density mentioned in Clause 310. In case of Road construction, where the height of embankment, as measured from formation level to the original ground level, is less than 200 mm, the embankment foundation shall be compacted in accordance with the requirements of Clause 310 such that the required compaction is achieved within the upper 300 mm below formation level.

Where necessary, embankment foundations shall be excavated/furrowed and brought under OMC and re-compacted in layers of 150 mm each in order to achieve the required level of compaction.

- (4) Embankments shall be built up evenly over the entire width and shall be maintained

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at all times with a sufficient camber to enable surface water to drain rapidly from them. Damage to compacted layers by constructional or other traffic shall be made good by the Contractor.

- (5) The natural moisture content and the optimum moisture content of the material to be placed in the embankment shall be checked before start of the placing material. If found to be out of the specified limits, the same shall be made good. Where water is required to be added in such constructions, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surface but without any flooding. Water shall be sprinkled uniformly and thoroughly mixed in soil by blading or harrowing until a uniform moisture content as specified is obtained.

Moisture content, checked in accordance with IS 2720 (Part 2), at the time of compaction shall be between 90% and 105% of the Optimum Moisture Content as determined in accordance with IS 2720 (Part 8).

If the material delivered for fill/backfill is too wet, it shall be dried by aeration and exposure to sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced by the above procedure, compaction work shall be suspended.

If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the specifications the Contractor shall

- (i) Make good by removing the material off the embankment and placing suitable material; or
  - (ii) Make good by tipping it elsewhere until it is in a suitable physical condition for re-use; or
  - (iii) Make good the material by mechanical or chemical means to improve its properties acceptable to the Engineer.
- (6) Where fill is required to be constructed across water logged or soft clayey ground that displays excessive movement under normal constructional equipment, it may be necessary to construct a capping layer.
- (7) Rock use in rock fill embankments shall be deposited in horizontal layers not exceeding 450 mm each extending up to the full width of the embankment.

Material shall be spread, levelled and compacted in accordance with Clause 310. Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments so formed shall be thoroughly blinded with approved well graded material to seal the surface

- (8) While filling embankment up to or over culverts or pipe drains, and where required in the contract, up to bridges, the Contractor shall bring the embankments up equally on both sides. In rock fill embankments the rock shall be carefully packed for such distance from the structure as is described in the contract.

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Where provision of filter membrane is specified behind structures, the same shall be laid in layers simultaneously with the laying of fill material.

### 310 COMPACTION OF EMBANKMENT AND OTHER AREAS OF FILL/BACKFILL

- (1) The Contractor shall obtain the Engineer approval of all fill layers before covering with subsequent layers.
- (2) All fill shall be compacted to the depth and degree of compaction as specified in Table 3.2 or as shown on the Drawing. Formation level if this context shall mean top of subgrade.

**Table 3.2: Compaction Requirements**

Location	Depth below Formation Level (mm)	Minimum Compaction (%MDD Heavy Compaction)
Roadway Embankment	0-300	95
Roadway Cut	0-300	95
All other roadway fills and backfill not separately specified		93

- (3) Each layer of rock used to fill in embankments shall be spread and levelled in accordance with Sub-clause 309 (7) and systematically compacted.
- (4) Layers of material other than rock fill shall not exceed 150 mm compacted depth unless and until the Contractor can demonstrate to the satisfaction of the Engineer that he can successfully Compact layers of a greater thickness.
- (5) Each layer shall be constructed in lengths suitable to the compaction and working methods used. Materials of each layer shall be thoroughly mixed with water as necessary to facilitate its compaction to the specified density.
- (6) In cut areas, the subgrade shall be processed as necessary and compacted to the depth and compaction requirements as given in Table 3.2. In the event that the Contractor is unable to achieve the minimum compaction requirements below formation level he shall excavate and re compact in layer as necessary.
- (7) Where it may be impracticable to use to conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory rollers, power rammers or plate compactor. Care shall be taken to ensure that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to it.

### 311 COMPACTION TRIALS

- (1) Before commencing filling embankment and from time to time as may be considered necessary by the Engineer, the Contractor shall carry out compaction trials in the presence of the Engineer on each of the main types of soil and rock fill to be used and compacted in the Works. He shall carry out all necessary laboratory and field testing as required by the Engineer and shall submit to the Engineer the results of all tests. The trial procedure shall include the compaction of trial areas selected by the Engineer.

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The surface of each area shall first be well compacted to the satisfaction of the Engineer. Each type of material being used shall be compacted in equal layers at uniform but differing moisture contents to a predetermined number of passes using the Contractor's proposed compaction equipment.

- (2) Following completion of the compaction trials, the Contractor shall submit to the Engineer, for his approval, his proposals for the compaction of each type of material to be encountered in the Works and its degree of compaction specified. The Contractor's proposals shall include reference to the types of equipment, the operating weights and type pressure, the methods of adjusting the moisture content, the number of passes and the loose depth of each layer.

If, in the opinion of the Engineer, the results of the compaction trials indicate that the Contractor's proposed plant and methods shall achieve the densities as specified, the Engineer shall approve the same. Otherwise the Contractor shall submit, in writing, proposals for modifying the plant and/or methods and shall, if the Engineer so requires, compact further trial areas in accordance with these modified proposals until the Engineer approves of Contractor's proposals.

- (3) When compaction of earthworks is in progress, the Contractor shall adhere to the compaction procedure approved by the Engineer.
- (4) Notwithstanding the Engineer's approval of any of the Contractor's plant or methods, the Contractor shall at all times be solely responsible for executing the earthworks in accordance with the Specifications and the Drawing.

### 312 BENCHING

- (1) Where embankment is to be constructed on hill slopes or slopes with more than or equal to 1 vertical to 4 horizontal slopes, benches with vertical and horizontal faces shall be cut into the existing slope (including rock) and the embankment shall be built up in successive layers. Where the cross slope is less than 1 vertical to 4 horizontal slope (other than rock) shall be loosened by scarifying to a depth of not less than 100 mm measured perpendicular to the slope, to ensure a good bond between the embankment and the embankment foundation. Material which has been loosened shall be covered with the first layer and compacted to the specified density simultaneously with the first layer of embankment material placed.

- (2) Where existing embankment are to be widened or included in a new embankment and slopes are not more than 1 vertical to 4 horizontals, the slope of the existing embankment shall be scarified to a depth of not less than 100 mm to ensure bond. Where the slope is less than 1 vertical to 4 horizontals, continuous horizontal benches, each at least 300 mm wide, shall be cut in existing slopes and the widened embankment shall be built up in successive layers of thickness of 150 mm to the level of old road.

Where the width of the widened portions is insufficient to permit the use of heavy rollers, compaction to the specified density shall be carried out with the help of small vibratory roller/plate compactor/rammer or other approved methods.

### 313 EARTHWORKS TO BE KEPT FREE OF WATER

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By providing temporary water course, ditches, drains, pumping or other means the Contractor shall arrange for the rapid dispersal of water from the areas of earthworks. Where practicable the water shall be discharged into permanent outfall for the drainage system. Adequate means for trapping silt shall be provided on temporary systems while discharging into permanent drainage systems.

### 314 WATERCOURSES

Excavations carried out in the diversion, enlargement, deepening or straightening of watercourses shall include the operations of any necessary trimming of slopes, grading of beds, disposal of excavated materials and pumping, tampering works and materials necessary for dealing with the flow of water.

### 315 FILLING EXISTING WATERCOURSES

Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits and filled in with suitable materials deposited and compacted as specified in Clauses 309 and 310.

### 316 PROCESS CONTROL

- (1) Throughout the works the Contractor shall perform tests to determine the suitability and compaction characteristics of soils to be used. The maximum dry density (MDD) and Optimum moisture content (OMC) test shall be conducted in accordance with IS 2720 Part 8 as specified in Table 8.8.
- (2) In addition to the foregoing tests, the Contractor shall carry out field density tests on the compacted fill materials in accordance with IS 2720 part 28/29. As specified in Table 8.8 and shall be carried out in each layer, including original ground surface on which embankment is to be constructed. If the result of any test shows that the minimum specified density has not been achieved, further compaction shall be executed to the area concerned and the layer re-tested. Unless the test results are satisfactory, the addition of another layer shall not be allowed.
- (3) The Contractor shall carry out tests for determination of moisture content at frequent intervals on all materials during the course of compaction as per Sub-clause 309 (5) to ensure that the requirements of Clause 310 are met with.

### 317 TEST FOR DISPERSIVE SOIL

Dispersive clays cannot be distinguished from nondispersive clays by conventional index tests such as gradation, Atteberg's limits, or compaction characteristics. The five laboratory tests most generally performed to identify dispersive clays are the crumb test (as specified in USBR 5400), the double hydrometer test (as specified in USBR 5405), the pinhole test (as specified in USBR 5410), the test of dissolved salts in the pore water, and the ESP (exchangeable sodium percentage) based tests.

However, results from the individual tests often do not agree, and the pinhole test is considered the most reliable since it is a direct physical test. It is emphasized that all of the tests should be performed on each soil sample for the most complete information and most reliable identification.

The primary requirement for taking soil samples in the field for any method of dispersive

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testing whether in the United States or elsewhere is to ensure that there is no moisture loss from the sample. Samples should be shipped to the laboratory in airtight containers. It is important that all soil specimens be maintained and tested at their natural water content since drying, especially oven drying, may alter dispersive characteristics.

### 318 LANDSLIDE CLEARANCE

This type of maintenance is required to deal with emergencies and problems calling for immediate action when canal/road and related system is threatening to be closed. Emergency maintenance requires timely assessment of canal/road slopes. Activities are removal of debris and other obstacles caused due to landslide, trimming and maintaining uniform slope, placement of warning signs, construction of diversion etc.

Assessment of canal/road slopes damages includes;

- Filling of Road closer forms and reporting to higher authority
- Removal of debris and other obstacles (Fallen tree/Landslip etc.)
- Trimming and maintaining of Slope as required
- Placement of warning signs
- Construction of diversion

### 319 DESILTING OF CANAL

#### A. GENERAL

Desilting of Canal also known as silt clearance is required to clear the silt deposited in canal bed and slope due to canal operation. This operation is inevitable to maintain the canal section and regulate the canal flow in capacity.

#### B. CONSTRUCTION

The silt deposited in the canal bed and slope shall be cleared manually or mechanically using excavator. Silt shall be cleared to maintain the true and uniform design shape (bed width and slope gradient) of the canal avoiding any residual undulation in order to the flow capacity. Silt excavated shall be disposed beyond the canal section. Silt can be deposited on outer slope of the canal if permitted by the Engineer.

### 320 MEASUREMENT

- (1) The quantities of the various classes of earthwork to be measured for payment under the contract shall be limited to the lines, grades, slopes and dimensions shown on the Drawing or as determined by the Engineer.
- (2) Except for foundation, all excavation including side drains, filling and backfilling compacted in place shall be measured in cubic meters by the average end area method as computed from the original and final cross-sections of the completed work. The distance between two end areas shall be the distance measured along central line of the canal/embankment. Where due to changed conditions, or the nature of a particular operation, or for any other reason, it is impossible or impractical to measure the quantities by means of average end areas, the Engineer shall compute the quantities by a volumetric method, if in his opinion, it is the best suited method

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to obtain an accurate determination.

No separate measurement for payment shall be made for excavation made on borrows, quarries, temporary works or in places outside the scope of permanent works specified in the contract.

Foundation excavation for structures shall be measured in cubic meters irrespective of all classes of materials except rock encountered. The quantities to be measured shall be the net cubic content of the voids formed by the removal of the materials enclosed between the bottom of the footing and existing ground level by a surface generated by vertical lines passing through the periphery of the bottom of the footing. No payment shall be made for any excavation other than the limited excavation described above. Excavation over increased width or length, cutting of slopes, removal of slides, shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for. Backfill to be measured shall be limited to this void only with due consideration of the nature of the structure.

Foundation excavation in rock shall be deemed to be covered by the rate for rock excavation.

- (3) Consumption of explosive materials, levelling, watering and compaction of original ground, construction of coffer dams, pumping out water and other ancillary and incidental works necessary to complete the item as per this specification shall not be measured for payment. They are deemed included in the measurement of the concerned item.
- (4) Unless stated otherwise, Lead and Lift of excavated materials for disposal shall not be measured for payment. They are deemed to be included in the quoted rates for the earthwork operations irrespective of haulage distance and lift height.
- (5) If the material obtained from canal excavation is used fully or partially in banks/embankments filling, the quantities for excavation and filling shall be computed as below.

The quantities of excavation and filling of the distances under reference shall be calculated separately adopting the method described as above in this Section. The computed quantity of filling shall be measured in filling while difference between quantities of excavation and filling shall be measured in excavation. The same excavated material shall not be measured both in excavation and filling.

### 321 PAYMENT

- (1) Various classes of earthworks i.e. excavation, filling, backfilling, additional leads and lifts measured as described above shall be paid at contract unit rate of the respective item.


The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of:

- (i) Arrangement of land as source of materials as much as needed.
- (ii) Process Control tests.
- (iii) Execution of all relevant operations described above in this Section and

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necessary to complete the item as per this specification.

- (2) Foundation excavation for structures, measured as described above, shall be paid for at the contract unit rate for all classes of excavation. The contract unit rate for foundation excavation shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of carrying out the required operations to excavate to the lines and levels as required by the Drawing or as directed by the Engineer.

  
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**SECTION 700: STONE WORKS**

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## SECTION 700: STONE WORKS

### 701 SCOPE

This Section covers the furnishing of materials and construction of different types of stone masonry works in accordance with the Drawing and this Specifications or as directed by the Engineer.

### 702 MATERIALS

#### (1) Stone

The stones to be used shall be durable and angular in shape. If boulders are used, they shall be broken into angular pieces. The stones shall be sound, hard, and free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. The specific gravity of the stone shall not be less than 2.50. Except otherwise described in the contract, the length of any stone shall not exceed three times its height. The breadth of the stone on the bed shall not be less than 150 mm nor greater than 3/4 the thickness of the wall. At least 85% of the stones used in masonry, except those used for chinking as chips or spalls of stones shall have individual volumes of more than 0.01 m<sup>3</sup>. The chips or spalls used including voids in the dry stone masonry shall not be more than 20% of the stone masonry by volume. In case of mortared masonry, the total volume of mortar and spalls taken together shall not be more than 30% of the mortared masonry. Representative samples of the stones intended for use in the works shall be submitted to the Engineer for prior approval. Further representative samples shall be submitted for approval whenever there is a change in the type or strength of the rock that the Contractor intends to use in masonry work.

#### (2) Mortar

Mortar for masonry shall conform to Sub-clause 602 (2).

### 703 CONSTRUCTION

The method of construction described herein shall hold in all Clauses of this Section, wherever applicable.

#### (1) General

Construction shall be carried out in accordance with I.S. 1597-1992, Code of Practice for construction of stone masonry, Part 1 Rubble stone masonry or Part 2 Ashlar Masonry as appropriate. All stratified stone possessing bedding planes shall be laid with its natural bed as nearly as possible at right angles to the direction of load. In the case of arch rings, the natural bed shall be radial. Face work groins shall be built to a height not exceeding one meter in advance of the main body of the work and adjacent walling stepped down on either side. Masonry face work between the groins shall then be built to a height not exceeding 500 mm above the backing which shall then be brought up level with the completed face work. At no time shall the backing be built up higher than the face work.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

Except for dry rubble walling, all joints (gaps) shall be sufficiently thick to prevent stone to stone contact and the gaps shall be completely filled with mortar. Stones shall be clean and sufficiently wetted before laying to prevent absorption of water from mortar.

Placing loose mortar on the course and pouring water upon it to fill the gaps in stones shall not be allowed. Mortar shall be fluid, mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all its faces completely covered with mortar of the thickness as specified for joints.

The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately after placement and solidly embedded in mortar before it has set. Clean and wet chips and spalls shall be wedged into the mortar joints and bed whenever necessary to avoid thick joints or bed of mortar. When the foundation masonry is laid directly on rock, the bedding face of the stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding over the rock. For masonry works over rock, a levelling course of M15/40 or M15/20 concrete 100mm thickness shall be laid over rock and then stone masonry work shall be laid without foundation concrete block.

In case, any stone already set in mortar is disturbed or the joints broken, it shall be taken out without disturbing the adjoining stones and joints. Dry mortar and stones thoroughly cleaned from the joints and the stones shall be reset in fresh mortar. Sliding one stone on top of another which is freshly laid, shall not be allowed.

Shaping and dressing of stone shall be done before it is laid in the work. Dressing and hammering of the laid stones which will loosen the masonry, shall not be allowed.

Building up face wall tied with occasional through stones and filling up the middle with stones spalls and chips or dry packing shall not be allowed. Vertical joints shall be staggered. Distance between the nearer vertical joints of upper layer and lower layer in coursed rubble masonry shall not be less than half the height of the course.

Masonry in a structure between two expansion joints shall be carried up nearly at one uniform level throughout but when breaks are unavoidable the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

Masonry shall not be laid when the air temperature in the shade is less than 3°C. Newly laid masonry shall be protected from the harmful effects of weather.

### (2) Concreting Capping

Where masonry structures are to receive a concrete capping. The joints to the upper surface of the masonry shall be raked out to a depth of 10 mm prior to placing of the concrete to the capping. The concrete for capping shall be as per the Drawing or as directed by Engineer and shall conform to Section 2000.

### (3) Pointing

Where external faces of the mortared masonry work will be backfilled or otherwise

permanently covered up, the mortared joint shall be finished flush to the faces of the adjacent stonework.

Where mortared masonry faces will remain exposed, the mortar joints shall be pointed to a consistent style as shown on the Drawing. Pointing shall be carried out using mortar 1:3 by volume of cement and sand or as shown on the Drawing. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing, if not otherwise mentioned shall be ruled type for which it shall, while masonry work is still green, be ruled along the centre with half round tools of such width as may be specified by the engineer. The excess mortar shall then, be taken off from the edges of the lines and shall not be unnecessarily plastered over the exposed stone works. The thickness of the joints shall not be less than 3mm for Ashlar masonry.

However, the maximum thickness of joints in different works shall be as follows:

Random Rubble: 20 mm

Coursed Rubble: 15 mm

Ashlar masonry: 5 mm

**704 ASHLAR**

All stones shall be dressed to accurate planes on the beds and joints and they shall be fair and neatly or fine tooled on the face unless otherwise described in the contract.

**705 BLOCK-IN-COURSE**

Beds and joints shall be squared and dressed for a distance of at least 220 mm from the exposed face. Bond stones shall form at least one sixth of the area of the exposed face and shall extend at least 900 mm into the wall or for the full thickness of the wall if the latter is less than 900 mm. Unless described in the contract as tooled or drafted, the exposed face of all stones shall be blocked and left rough. Arises shall be dressed square at all beds and joints.

**706 SQUARE RUBBLE-COURSED OR BROKEN COURSE**

All stones shall be truly squared and dressed for a distance at least 120 mm from the face of the wall. Bond stones shall be provided at the rate of at least one to every 0.8 m<sup>2</sup> of exposed face and shall measure not less than 150 mm x 150 mm on the face and not less than 450 mm in length or the full thickness of the wall, whichever is the less. Vertical joints in any layer shall be broken in the next layer and the horizontal lapping of the stones shall not be less than 100 mm.

**707 RANDOM RUBBLE-COURSED OR UNCOURSED**

All stones shall be carefully set with a bond stone provided at the rate of at least one to every 0.9 m<sup>2</sup> of exposed face. Bond stones shall measure not less than 150 mm x 150 mm on the exposed face and not less than 450 mm in length or the full thickness of the wall, whichever is the less.

**708 DRY RANDOM RUBBLE**

Dry random rubble masonry shall be constructed generally to the requirements of coursed random rubble masonry as specified in Clause 2607 but with the omission of mortar. All stones shall be carefully shaped to obtain as close a fit as possible at all beds and joints, any interstices between the stones being filled with selected stone spalls. The stones in courses shall be laid perpendicular to the batter face. The exposed tops or capings of dry rubble structures shall be formed as shown on the Drawing.

**709 COMPOSITE RANDOM RUBBLE**

Materials for composite random rubble shall comply with Clause 2602 and construction with Clause 2603. Mortar masonry shall be coursed and comply with Clause 2607 and the dry stone insets with Clause 2608. The dry stone insets shall be constructed when the level of the surrounding mortared masonry surround has reached the top of the dry stone inset.

**710 CONCRETE BLOCKS**

**A. CONCRETE MESH BLOCK**

Concrete mesh block which is lighter but durable than solid concrete block shall be laid in 1:4 Cement sand mortar as specified in the BoQ. The finished surface should be smooth and lightening. After the wall constructed with concrete mesh block, it should be properly cured to attain the required strength.

Mortar for masonry shall conform to Sub-clause 602 (2).

**B. CONCRETE HOLLOW BLOCK**

Concrete hollow blocks which are commonly used in walls, partition and foundation shall be laid in 1:4 and 1:6 cement sand mortar as required and specified in the BoQ. The size of the block should be 200mm x 200mm x 150mm unless otherwise specified. The ratio of cement sand mortar may be different if specified other way in the BoQ of contract document. The finished surface should be smooth and shining. After the wall constructed with concrete hollow block, it should be properly cured to attain the required strength.

Mortar for masonry shall conform to Sub-clause 602 (2).

**C. AUTOCLAVED AERATED CONCRETE (AAC) BLOCK**

Autoclaved Aerated Concrete blocks which are commonly used in residential and commercial buildings for walls, roofing, and partitions shall be laid in 1:4 and 1:6 cement sand mortar as required and specified in the BoQ. The size of the block should be 600mm x 200mm x 200mm unless otherwise specified. The ratio of cement sand mortar may be different if specified other way in the BoQ of contract document. The finished surface should be smooth and glowing. After the wall constructed with AAC block, it should be properly cured to attain the required strength.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

Mortar for masonry shall conform to Sub-clause 602 (2).

### D. CONCRETE SOLID BLOCK

Concrete solid blocks which are commonly used in foundations, walls, and structures requiring high durability shall be laid in 1:4 and 1:6 cement sand mortar as required and specified in the BoQ. The size of the block should be 400mm x 200mm x 200mm unless otherwise specified. The ratio of cement sand mortar may be different if specified other way in the BoQ of contract document. The finished surface should be smooth and shining. After the wall constructed with concrete solid block, it should be properly cured to attain the required strength.

Mortar for masonry shall conform to Sub-clause 602 (2).

### 711 TEST AND STANDARD OF ACCEPTANCE

Before laying any mortar, the Contractor shall make three sets of mortar test cubes from each source of sand to demonstrate the compliance of the mix to the specified strength. Each set shall comprise two cubes, one to be tested at 7 days and the other to be tested at 28 days. During construction, the Contractor shall make and test mortar cubes at the rate of three cubes for every 10m<sup>3</sup> of masonry to assess the strength subject to a minimum of 3 cubes samples for a day's work. Testing of cubes shall be in accordance with IS: 2250. The stones shall be tested for the water absorption as per IS: 1124 and it shall not be more than 5 percent. The stones shall also be tested for Specification gravity and it shall not be less than 2.65. Sand shall be tested as per Clause 613 or as directed by the Engineer. At least 3 set of tests for stone and sand shall be conducted for every source.

### 712 MEASUREMENT

Stone masonry shall be measured in cubic metres. The pointing shall be measured in sq. m.

### 713 PAYMENT

The stone masonry and the pointing shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 112.

STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS



  
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## SECTION 800 – CEMENT CONCRETE WORKS

### 801 SCOPE

This Section named Cement concrete works covers the materials required, design of mixes, transport, placing, compaction and curing of concrete and mortar required for different concrete works for concrete structures. It also covers steel reinforcement for concrete.

### 802 DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced, pre-stressed or unreinforced concrete construction which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling foundations and similar purpose where it is not subjected to significant stress.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc. and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

### 803 MATERIAL FOR CONCRETE

#### (1) General

The Contractor shall submit to the Engineer full details of all materials which he purposes to use for making concrete. No concrete shall be placed in the works until the Engineer has approved the materials of which it is composed. Approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

#### (2) Cement

Cement shall comply with the requirements of Clause 602.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level not less than 30 cm and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation with min gap of 500 mm from outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. Stack of cement bags shall not exceed 8 bags in height. Different types of cement in bags shall be clearly distinguished by visible marking and shall be stored in separate stacks.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

Cement from broken bags shall not be used in the works. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weather proof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement for any one structure shall be from the same source as far as possible.

All cement used in the works shall be tested by the manufacturer. The manufacturer shall provide the results of tests as given in Table 6.6 for each supply and for the last six months of his production.

Each set of tests carried out by the manufacturer on samples taken from cement which is subsequently to site shall relate to no more than one day's output of each cement plant.

The Contractor shall constitute each type of cement and required number of representative samples to be tested when instructed by the Engineer in a laboratory acceptable to him, in case of the concrete mixes do not comply with the requirements of this Specification.

Cement which is stored on site for longer than one month shall be tested in such laboratory for every 200 tons or part thereof and at monthly intervals thereafter.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and the cement used in the works and shall provide the Engineer with two copies thereof.

### (3) Fine Aggregate

Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with IS 383. All the material shall be in accordance Table 8.1.

**Table 8.1 Grading Requirement for fine aggregate**

IS sieve designation (mm)	Percentage passing
10	100
4.75	90-100
2.36	75-100
1.18	55-90
0.60	35-59
0.30	8-30
0.15	0-10

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In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source. The deviation from the initial fineness modulus shall be no more than  $\pm 0.30$  for ordinary concrete and  $\pm 0.20$  for high quality concrete.

However, in respect of the presence of deleterious materials the fine aggregate shall not contain iron pyrites, iron oxides, mica, shale, coal or other laminar soft or porous materials or organic matter unless the Contractor can show by comparative tests on finished concrete as set out in Table 8.4 and as per the direction of the Engineer, that presence of such materials does not affect the properties of the concrete.

#### (4) Coarse Aggregate

Coarse aggregate shall be clean, clear, dense, hard, strong and durable crushed rock, crushed gravel or natural gravel. As far as possible, flaky, coriaceous and elongated pieces should be avoided. Coarse aggregate shall be supplied in the nominal size called for in the contract and shall be of the grading as specified in Table 8.2.

**Table 8.2 Grading Requirement for Coarse Aggregate**

S.N	IS sieve Designation	Percentage Passing for Single Sized Aggregate of nominal Size						Percentage Passing for Graded Aggregate of Nominal Size			
		63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
i)	80 mm	100						100			
ii)	63 mm	85-100	100								
iii)	40 mm	0-30	85-100	100				90-100	100		
iv)	20 mm	0-5	0-20	85-100	100			30-70	90-100	100	100
v)	16 mm				85-100	100				90-100	
vi)	12.5 mm					85-100	100				90-100
vii)	10 mm	0-5	0-5	0-20	0-30	0-45	85-100	10-35	25-35	30-70	40-85
viii)	4.75 mm			0-5	0-5	0-10		0-5	0-10	0-10	0-10
ix)	2.36 mm										

Other properties shall be set out below:

**Flakiness Index:** When tested in accordance with IS 2386 Part 1, the Flakiness Index of the coarse aggregate shall be as set out hereunder:

For ordinary concrete : not more than 25  
 For high quality concrete : not more than 15

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected by such variation.

**Water Absorption:** the aggregate shall not have a water absorption of more than 2 per cent when tested as set out in IS: 2386 Part 3.

**Los Angeles Abrasion (LAA):** The aggregate shall have LAA not more than 50% for ordinary concrete, and not more than 30% for high quality concrete (wearing surface), when tested in accordance with IS: 2386 Part 4.

**Aggregate Crushing Value (ACV):** The aggregate shall have ACV not more than 30% for wearing surfaces such as road and pavement structure and not more than 45% for other structure when tested in accordance with IS: 2486 Part 4.

**Alkali Aggregate Reactivity (AAR):** Coarse aggregates having positive alkali-silica reaction shall not be used for concreting. The aggregate shall comply with IS 456 when tested in accordance with IS: 2386 Part 7.

### (5) Testing Aggregate

#### (a) Acceptance Testing

The Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposed to use in the works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labeled to show its origin and shall be accompanied by all information called for in IS: 2386 Part 1 to 8.

Tests to determine compliance of the aggregates with the requirements of sub-clause 803 (3) and (4) shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer. Acceptance of the material shall be based on the results of such tests.

All the materials shall be accepted if the results of not less than three consecutive sets of test executed in accordance with IS 2386 (Part 1-8) show compliance with the Sub-clause 803 (3) and (4).

#### (b) Compliance Testing/Process Control Testing

The Contractor shall carry out routine testing of aggregate for compliance with the Specification during the period that concrete is being produced for the works. Frequency test shall be as follows:

		Test procedure	Frequency
Fine aggregate and	Grading Silt, Clay Contents and Organic Impurities	IS: 2386 Part 1 IS: 2386 Part 2	1 set ( 3 nos ) test for each 10 to 50 cum and additional test for each 50 cum of concrete

STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

Coarse Aggregate	Grading Silt, Clay Contents and Organic Impurities	IS: 2386 Part 1 IS: 2386 Part 2	1 set ( 3 nos ) test for each 25 to 125 cum and additional test for each 125 cum
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If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Engineer. Chloride Content: As frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

Sulphate Content and Alkali Aggregate Reactivity: As frequently as may be required according to the variability of sulphate content and alkali reactivity assessed from the laboratory test carried out during the concrete mix design.

**(6) Delivery and Storage of Aggregate**

Aggregate shall be delivered to site in clean and suitable vehicles. Different type or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that the contamination of aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregate shall be arranged in such a way that drying out in hot weather is prevented in order to avoid fluctuations in water content. Storage of fine aggregates shall be arranged in such way that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

**(7) Water for Concrete Mortar**

Water shall be reasonably clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may deleterious to concrete or steel.

The Contractor shall carry out tests in compliance with IS 456 to establish compliance with Specifications.

**(8) Admixture**

**(a) General**

The use of admixtures in concrete may be required under the contract to promote special properties in the finished concrete or may be proposed by the Contractor to assist him in compliance with the Specification.

In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it in the mix. The information provided shall include:

- (i) The typical dosage, the method of dosing, and the detrimental effects of an excess or deficiency in the dosage.
- (ii) The chemical names of the main active ingredients in the admixture.
- (iii) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.
- (iv) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so the extent to which it does so.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

- (v) Details of previous uses of the admixture in Nepal.

Admixture/additives conforming to IS 9103 may be used subject to approval of the Engineer. However, admixture/ additives generating hydrogen or nitrogen and containing chlorides, nitrates, sulphides, sulphates or any other material likely to adversely affect the steel or concrete shall not be permitted.

Compatibility of the admixtures with the cement and any other pozzolan or hydraulic addition shall be ensured by for avoiding the following problems.

- (i) Requirement of large dosage of superplasticizer for achieving the desired workability.
- (ii) Excessive retardation of setting
- (iii) Excessive entrainment of large bubbles
- (iv) Unusually rapid stiffening of concrete
- (v) Rapid loss of slump
- (vi) Excessive segregation and bleeding

### (9) Curing Material

Curing of Concrete may be done by using water, steam and membrane forming compounds. Approved membrane forming curing compound consisting of waxes, resins, chlorinated rubbers etc may be used, which shall be applied to all exposed surface of the concrete as soon as possible after the concrete has set. Impermeable membrane such as sheet materials conforming to ASTM C 171 or polythene sheeting covering closely the concrete surface may also be used to provide effective barrier against evaporation.

## 804 DESIGN OF CONCRETE MIXES

### (1) Classes of Concrete

The classes of structural concrete to be used in the works shall be as shown on the Drawing. Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 8 of IS 456: 2000 may be assumed for design of mix in the first instance. As soon as the results of samples are available, actual calculated standard deviation shall be used and the mix designed properly for reference Table 8.3 may be used, in which the class designation includes two figures. The first figures indicate the characteristic strength  $f_{ck}$  at 28 days expressed in  $N/mm^2$  and the second figure is the maximal nominal size of aggregate in the mix expressed in millimeters. Letter M in the class designation stands for Mix, letter SM stand for Special Mix.

Consistence of the mix, assessed through the Slump Test where the slump is measured in millimeters, is designate as follows:

S: Stiff consistence, for slump  $\leq 40$

P: Plastic consistence, for slump  $> 40$  and  $\leq 90$

VP: Very Plastic consistence, for slump  $> 90$  and  $\leq 150$

F: Flowing consistence for slump  $> 150$

**Table 8.3: Concrete Classes and Strength**

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Classes of Concrete	Consistence	Type of uses	Characteristic Strength $f_{ck}$ (N/mm <sup>2</sup> )	Maximum Nominal Size of Aggregate mm	Trial mixes Minimal Target Strength $f_{ck}=f_{ck} + 1.65 \cdot S$ (N/mm <sup>2</sup> )	Early works test cubes		Concrete mix
						Any one result (N/mm <sup>2</sup> )	Average of 3 consecutive results (N/mm <sup>2</sup> )	
M 10/75	S	Ordinary	10	75	16	7	14	Designed / Prescribed
M 10/40	S	Ordinary	10	40	16	7	14	
M 15/20	S	Ordinary	15	20	21	12	19	Designed
M 15/40	S	Ordinary	15	40	21	12	19	
M 20/20	S	Ordinary	20	20	27	16	24	Designed
M 20/40	S	Ordinary	20	40	27	16	24	
M 25/20	S	Ordinary	25	20	32	21	29	Designed
M 25/40	S	Ordinary	25	40	32	21	29	
M 30/40	P	High Quality	30	40	38	26	34	Designed
M 30/20	P	High Quality	30	20	38	26	34	
M 30/12	P	High Quality	30	12	38	26	34	Designed
M 35/40	P	High Quality	35	40	43	31	39	
M 35/20	P	High Quality	35	20	43	31	39	Designed
M 40/20	P	High Quality	40	20	48	36	44	
M 45/20	P	High Quality	45	20	53	41	49	Designed
M 50/20	P	High Quality	50	20	58	46	54	
M 55/20	P	High Quality	50	20	63	51	59	Designed
SM 30/40	VP	Underwater	30	40	38	26	34	
SM 30/20	VP	Underwater	30	20	38	26	34	Designed
SM 30/20	F	Bored Piles	30	20	38	26	34	
SM 40/20	S	Precast Piles	40	20	48	36	44	Designed
SM 45/20	S	Post-tensioned Girders	45	20	53	41	49	

(2) Design of Proposed Mixes

Concrete mixes shall comply with the following requirements:

Sampling and testing on concrete shall be carried out in accordance with the standard methods given in the Table 8.4

Table 8.4 Tests Procedures Applicable to Concrete

SN	Tests	Test Procedure
(i)	Air contents of fresh concrete	IS: 1199
(ii)	Density of hardened concrete	IS: 516
(iii)	Compressive strength of concrete cubes	IS: 516
(iv)	Tensile splitting strength	IS: 5816
(v)	Flexural strength	IS: 516
(vi)	Compressive strength of concrete cores	IS: 516
(vii)	Water absorption	

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(viii)	Mixing and sampling fresh concrete in laboratory	IS: 516
(ix)	Normal curing of test specimens	IS: 516
(x)	Accelerated curing of test specimens	IS: 9013
(xi)	Marking test cubes from fresh concrete	IS: 516

Non-destructive tests shall be carried out in accordance with the standard method and recommendations given in Table 8.5 as and when required.

**Table 8.5: Non-destructive Tests Applicable to Concrete**

S.NO	Test	References to Test Procedures
(i)	ULTRASONIC PULSE VELOCITY (UPV))	IS: 13311 part-1
(ii)	Rebound hammer	IS: 13311 part-2
(iii)	Pull out test [ method of testing bond in reinforcement concrete]	IS: 2720 part - 1
(iv)	RADIOGRAPHIC METHODS	BS: 1881 -205
(v)	BACKSCATTER RADIOMETRY (BSR) (Nuclear surface moisture density gauge)	ASTM C 1040
(vi)	IMPACT-ECHO	ASTM C 1383
(vii)	COVER METER and Bar locator	BS: 1881 204
(viii)	Core test	IS: 516
(ix)	Corrosion assessment/ Half-cell potential	ASTM C 876-9

The test specimens shall be cured at a temperature of  $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$

Water used for concrete shall comply with all the requirement given in Table 8.6 Water to be used in concrete shall be tested as specified in IS: 3025

**Table 8.6 Permissible limit for solids for water used in concrete**

S.NO.	Permissible limit , Max	Test Procedure
(i)	200 mg/l	IS: 3025 part 18
(ii)	3000 mg /l	IS: 3025 part 18
(iii)	400 mg/l	IS: 3025 part 24
(iv)	2000 mg/l, for concrete not consisting embedded steel and 500 mg/l for RCC work	IS: 3025 part 32
(v)	200 mg/l	IS: 3025 part 17

The total chloride content, expressed as chloride ion, arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as a percentage of the weight of cement in the mix:-

For pre-stressed concrete, steam cured concrete or concrete containing percent sulphate resisting or super sulphated cement -0.1

For any other reinforced concrete - 0.4 percent

The total sulphate content expressed as  $\text{SO}_3$  of all the ingredients in a mix including cement water and admixtures shall not exceed 0.4 percent by weight of the aggregate or 4.0 percent of the weight of the cement in the mix, whichever is the lesser.

The contractor shall design all the concrete mixes called for in the Drawing using the ingredients which have been approved by the Engineer in accordance with Clause 803 and in compliance with the following requirements:

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- (a) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150-micron size.
- (b) The cement content shall be such to achieve the strength called for in Table 8.3 but in any case not less than the minimum necessary as shown in Table 8.7.
- (c) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.
- (d) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than 0.5 for classes of concrete higher than M20 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.
- (e) For each class of concrete Contractor shall conduct laboratory trial as mentioned in 804(3) based on the results of these trials the contractor shall submit full details of his proposal including the result of test to the Engineer for approval. However, Engineer's approval shall not relieve the contractor from his responsibilities for compliance with these specifications.
- (f) The cement content shall not be more than 450 kg/ m<sup>3</sup> unless special consideration has been given in design to cover the risk of cracking due to drying and shrinkage in thin sections or to early thermal cracking and to the increased risk of damage due to alkali silica reactions.

**Table 8.7: Minimum Cement Content and Maximum water cement ratio**

SN	Exposure	Minimum cement Content in kg/ cu.m.	Maximum free water cement ratio	Minimum Grade of Concrete
A. Plain Cement concrete				
1	Mild	220	0.6	
2	Moderate	240	0.6	M15
3	Severe	250	0.5	M20
B. Reinforced Cement concrete				
1	Mild	300	0.55	M20

**Note:**

1. The minimum cement contents shown in the above table are required in order to achieve impermeability and durability having 20 mm size aggregate, in case of 10 mm size add 40 kg/ m<sup>3</sup> and in case of 40 mm size aggregate reduce up to 30 kg/ m<sup>3</sup>. In order to meet the strength requirements in the Specification higher contents may be required.

2. Exposure can be classified as

*Mild: Concrete surface protected against weather or aggressive conditions Moderate: Concrete surfaces sheltered from severe rain or freezing whilst wet concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non-aggressive soil/ ground water.*

*Severe: Concrete surface exposed to severe rain, alternate wetting and drying or occasional freezing whilst or severe condensation*

### (3) Prescribed Mixes

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Prescribed mixes shall have the proportion mentioned below

Classes of concrete	Type of uses	Characteristic Strength fck (N/mm <sup>2</sup> )	Concrete mix	Mix proportion in case of Prescribed mix
M 10/75	Ordinary	10	Prescribed	1:3:6
M 10/40	Ordinary	10		1:3:6
M 15/20	Ordinary	15		1:2:4
M 15/40	Ordinary	15		1:2:4

Concrete mix shall be proportioned by volume. The Engineer may instruct to slight adjustment in the proportioning to allow for variations in the specific gravity and grading of aggregates. Such variation shall not be deemed to vary the price of the concrete. The Engineer shall require the contractor to make trial mixes and test work cubes to satisfy himself that the prescribed mix will give expected strengths. No concrete shall be placed in the works until the relevant mix has been approved by the Engineer and no variation shall be made in the mix after approval without the Engineer's consent, who may require further tests to be made.

(4) Laboratory Trial Mixes

For each mix of concrete the Contractor shall prepare three number of concrete batches with the proportion as per designed or prescribed mix as specified in the contract. The Following test shall be carried out for each sample of each batch.

- Slump Test
- Compressive strength Test of each concrete cube. [six test cubes from each batch shall be prepared and 3 cubes shall be tested for 7 days and 3 for 28 days]
- Density Test (of Concrete cubes)

Modified compositions, the quantities of other constituents being unchanged:

Water	:	+10%	1 batch
Water	:	-10%	1 batch
Cement	:	+15%	1 batch
Cement	:	-15%	1 batch

Samples shall be taken from each batch and the following action taken, all in accordance with IS: 516.

(\*) For "Smaller Contracts Works", the following composition are suggested as a

Concrete Class	Characteristic Strength N/mm <sup>2</sup>	Cement (kg)	Total Aggregate (kg)	Fine aggr. / Total aggr. (%)	Water (max) (lit.)	Workability
M 15/40	15	250	1900	35-45	160	Stiff-Plastic
M 15/20						
M 20/20	20	300	1875	35-45	165-170	Stiff
M 30/40						
M 30/20						
M 35/20	35	350	1825	35-45	175	Plastic

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starting basis for the Laboratory trials for one cu.m of concrete.

A "result" being the average strength of the three cubes from one batch, the average of the three results from tests at 28 days for the nominal composition shall not be less than the Minimal Target Strength shown in Table 8.3.

One result from the modified compositions shall not be less than the nominal strength as shown on Table 8.3.

### (4) Site Trials

At least six weeks before commencing placement of concrete in the permanent works, site trials shall be prepared for each class of concrete specified.

For each mix of concrete for which the Contractor has proposed a design and successfully tested in Laboratory, he shall prepare three separate batches specified hereunder using the materials which have been approved for use in the works and the mixing plant which he propose to use for the works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the action taken similar to the above Sub-clause 804 (2) (a) to (e)

The average of the three results of tests at 28 days shall not be less than the Minimal Target Strength shown in Table 8.3.

The Contractor shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Engineer.

Based on the results of the tests on the Laboratory trial and site trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, and the results of the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the works without the written consent of the Engineer.

### (5) Quality control of Concrete Production

#### (a) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described in IS: 516 and with the further requirements set out below.

Six 150 mm or 200 mm cubes(1 Set) as appropriate shall be made from each sample and shall be cured and tested in accordance with IS: 516 three at seven days and the other three at 28 days. Where information samples are required, such as for post tensioning operations, three additional cubes shall be made.

The minimum frequency of sampling of concrete of each grade shall be as following:



  
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For 1-5 m <sup>3</sup> quantity of work at one place	- 1 set of sample
For greater than 5-15 m <sup>3</sup> quantity of Work	- 2 set. of sample
For greater than 15-30 m <sup>3</sup> quantity of work	- 3 set. of sample
For greater than 30-50 m <sup>3</sup> quantity of work	- 4 set. of sample
For more than 50 m <sup>3</sup> quantity of work	4 set .of sample plus one additional foreach 50 m <sup>3</sup> or part thereof.

At least one set of sample shall be taken from each shifts of work.

Until compliance with the Specification has been established the frequency of sampling shall be three times that stated above and not less than 3 samples/day for each class of concrete in production at each plant or such lower frequency as may be instructed by the Engineer.

**(b) Testing**

(i) The slump of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the point of production and deposition or at the frequency instructed by the Engineer.

The slump of concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value whichever is the less.

(ii) The air content of air entrained concrete in any batch shall be within 1.5 times of the required value and the average value of four consecutive measurements shall be within the required value expressed as a percentage of the volume of freshly mixed concrete while tested according to IS: 1199.

(iii) Early Works: Until such times as sufficient test results are available to apply the method of control described in (iv) below, the compressive strength of the concrete at 28 days shall be such that no result (average of 3 cubes) is less than the characteristic strength  $f_{ck}$  as shown in Table 8.3 under the heading "early works test cubes" and also that the average of three consecutive results in not less than  $f_{ck} + 4$  as shown in Table 8.3 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

(iv) When at least 20 consecutive results on tested batches are available for any class of concrete mixed in any one plant, no single result shall be less than  $f_{ck} - 4$  (N/mm<sup>2</sup>) and also the average of any group of three consecutive results shall not be less than  $f_{ck} + 4$  (N/mm<sup>2</sup>).

In addition, the Coefficient of Variation shall be less than the figure given below:

Number of Batches	Maximum coefficient of variation	
	Ordinary concrete	High quality concrete
After 20 tested batches	18%	15%
After 50 tested batches	15%	12%

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Where the Coefficient of Variation =  $\frac{\text{Standard Deviation of the results}}{\text{Average Value of the results}}$

(v) Failure to comply with requirements:

If any one result in a group of three consecutive results is less than  $f_{ck} - 4$  ( $\text{N/mm}^2$ ), but the other results of group satisfy the strength requirement, then only the batch from which the failed result was obtained shall be deemed not to comply with the Specification.

If the average strength of the group is less than the strength requirement then all the batches between those represented by the first and the last result shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the production procedure or the mix design subject to the agreement of the Engineer to restore compliance with the Specification. If Adjustment of the mix design is agreed, the Contractor shall again be required to comply with Sub-clauses 804 (3) and 804 (4).

The Contractor shall take necessary action to remedy concrete which does not comply with this Specification. Such action may include but not necessarily confined to the following:

Increasing the frequency of sampling until control is again established.

Carrying out non-destructive testing such as ultrasonic measurement, load tests or other appropriate methods.

Cutting test scores from the concrete and testing in accordance with IS: 1199.

Carrying out strengthening or other remedial work to the concrete where possible or appropriate.

Removing the concrete.

**805 MIXING CONCRETE**

**(1) Proportioning**

Concrete mixes shall be proportioned according to the Design mix or prescribed mix as specified. All mixing operations shall be supervised by experienced supervisor. Cement and aggregate shall be batched by weight or by volume as specified in the contract. Water may be measured by weight or volume. The quantity of cement, each size of aggregate and water as indicated by the mechanism employed shall be within a tolerance of plus or minus three percent of the respective weight/ volume per batch agreed by the Engineer. The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer.

**(2) Machine Mixing**

Concrete for the work shall be batched and mixed in one or more plants or concrete mixer unless the Engineer agrees to some other arrangement. If concrete mixers are used, there shall be sufficient number of mixtures including stand by mixers.

Batching and mixing plants shall be complying with the requirements of IS: 1791 and

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capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixers shall comply with the requirements of IS: 4925 and shall only be used with the prior approval of the Engineer. If the plant proposed by the Contractor does not fall within the scope of IS: 1791 it shall have been tested in accordance with IS: 4634 and shall have a mixing performance within the limits of IS: 1791.

All mixing operations shall be under the control of an experienced supervisor

The aggregate storage bins shall be provided with drainage facilities arranged so that the drainage water is not discharged to the weigh hoppers. Each bin shall be drawn at least once per week and any accumulations of mud or silt shall be removed

If bulk cement is used, the scale and weight hopper for cement shall be distinct from the scale and weight hopper for aggregates.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or the pan.

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixers shall be cleaned out before changing to another type of cement.

### (3) Hand Mixing

Concrete for structural purposes generally shall not be mixed by hand. However, for small volumes of works and where non-structural concrete is required, hand mixing may be carried out subject to approved of the Engineer.

For making hand mixing concrete, cement, sand and aggregate shall be batched separately by volume or by weight as applicable. Then cement and sand shall be mixed dry to uniform colour. The aggregate shall be stacked in a proper shape upon which cement sand mix shall be spread and whole mix shall be mixed to uniform consistency.

For hand mixed concrete the specified quantities of cement shall be increased by 10 % and not more than 0.25 cubic meter shall be mixed at one time. During windy weather precautions shall be taken to prevent cement from being blown away in the process of gauging and mixing.

## 806 TRANSPORTATION OF CONCRETE

The concrete shall be discharged from the mixer and transported to the works by means which shall prevent adulteration, segregation or loss of ingredients, and shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall be within the tolerances specified in

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Sub-clause 804 (5) (b) (i).

The capacity of the means of transport shall not be less than the full volume of a batch.

The time elapsing between mixing transporting placing and compacting altogether of a batch of concrete shall not be longer than the initial setting time of the concrete. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the works.

**807 PLACING OF CONCRETE**

**(1) Consent for Placing**

Concrete shall not be placed until the Engineer's consent has been given in writing. The Contractor shall give the Engineer at least two full working day notice of his intention to place concrete.

If concrete placing is not commenced within 24 hours of the Engineer's consent the Contractor shall again request consent as specified above.

**(2) Preparation of Surface to Receive Concrete**

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 300.

Existing concrete surfaces shall be prepared as set out in Clause 812. Before deposition of further concrete, they shall be clean, hard and sound and shall be wet but without any free standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump or be removed by other suitable which will prevent washing away the freshly deposited concrete or any of its constituents. Any under drain constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

Unless otherwise instructed by the Engineer surfaces against which concrete is to be placed shall receive prior coating of cement slurry or mortar mixed in the proportions similar to those of the fines proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be placed into all parts of the excavated surface and shall not be less than 5 mm thick.

If any fissures have been cleaned out they shall be filled with mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at one time shall be limited so that it does not dry out or set before being covered with concrete.

**(3) Placing Procedures**

The Concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items or form work. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 300 mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the

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layers shall not be thinner than four times the maximum nominal size of aggregate.

When placing on a nearly horizontal surface, placing shall start at the lower end of the surface to avoid decompaction of concrete.

Layers shall not be placed so that they form feather edges nor shall they be placed on a previous layer which has taken its initial set. In order to comply with this requirement, another layer may be started before initial set of the preceding layer.

All the concrete in a single bay or pour shall be placed as a continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of compacted concrete with no segregation or honey combing. It shall also be carefully worked round and between water stops, reinforcement, embedded steelwork and similar items which protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be complied with.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In dry weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged from the place above its final deposition, segregation shall be prevented by the use of chutes, down pipes, trunking, baffles or other appropriate devices.

Forms for walls shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the Contractor shall submit to the Engineer his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continuously full with concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the level of concrete in a tremie pipe is allowed to fall to such extent that the water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position. During and after concreting under water, pumping or dewatering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

**(4) Interruptions to Placing**

If the concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete in accordance with Clause 808. All work on the concrete shall be completed before elapse of initial setting time and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all time during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remedy all damaged or uncompacted concrete, feather edges or any undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

In case of long interruption concrete shall be resumed as directed by Engineer.

**(5) Dimension of Pours**

Unless otherwise agreed by the Engineer, pours shall not be more than two meters high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the circumstances described in Sub-clause 807 (4).

The Contractor shall plan the dimensions and sequence of pours in such a way that cracking of the concrete does not take place due to thermal or shrinkage stresses.

**(6) Placing Sequence**

The Contractor shall arrange that the intervals between successive lifts of concrete in one section of the works are of equal duration. This duration shall not be less than three days or not more than seven days under temperate weather conditions unless otherwise agreed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete which is less than 21 days old.

Contraction gaps in concrete shall be of the widths and in the locations as shown on the Drawing and they shall not be filled until the full time interval shown on the Drawing has elapsed.

**808 COMPACTION OF CONCRETE**

Concrete shall be fully compacted throughout the full extent of the placed layer. It shall thoroughly worked against the formwork and around any reinforcement and other embedded item, without displacing them. Care shall be taken at arises or other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

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Concrete shall be compacted with the assistance of mechanical of immersion vibrators, unless the Engineer agrees another method.

Immersion and surface vibrators shall operate at a frequency of between 70 and 200 hertz. The Contractor shall ensure that vibrators are operated at pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, stand-by vibrators shall be available for instant use at each place where concrete is being placed.

Vibration shall be continued at each until the concrete ceases to contract, air bubbles have ceased to appear, and a thin layer of mortar has appeared on the surface. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective and some extent of vibration is overlapped.

Vibration shall not be applied by way of reinforcement nor shall the vibrator be allowed to touch reinforcement, sheathing ducts or other embedded items.

### 809 CURING OF CONCRETE

#### (1) General

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperatures differentials within the concrete sufficient to cause cracking. Concrete shall be cured with wet cotton mat, sheet material or other compound for curing approved by the Engineer. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but not less than seven days or until the concrete is covered by successive construction whichever is the shorter period.

The above objectives shall be dealt with in Sub-clauses 809 (2) and 809 (3) but nothing shall prevent both objectives being achieved by a single method where circumstances permit.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process. In the case of large areas or continuous pours, it shall commence on the completed section of the pour before the rest of the pour is finished.

#### (2) Loss of Moisture

Exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300 mm.

If it is not possible to use impermeable sheeting, the Contractor shall keep the exposed surfaces continuously wet by means of water spray or by covering with a water



  
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absorbent material which shall be kept wet, unless this method conflicts with Sub-clause 809 (3).

Water used for curing shall be of the same quality as that used for mixing.

Formed surfaces may be cured by retaining the formwork in place for the required curing period.

Alternatively, Approved curing compound shall be used to cover exposed surface.

If instructed by the Engineer, the Contractor shall, in addition to the curing provisions set out above provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

### (3) Limitation of Temperature Differentials

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances including the following:

- (a) limiting concrete temperatures at placing as set out in Sub-clause 811 (2);
- (b) use of low heat cement for mass concreting, subject to the agreement of the Engineer;
- (c) Leaving formwork in place during the curing period. Steel forms shall be suitably insulated on the outside;
- (d) Preventing rapid dissipation of heat from surfaces by shielding from wind.

## 810 PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

Concrete placed in the works shall not be subjected to any loading including traffic until it has attained at least its characteristic strength as defined in Clause 804.

## 811 CONCRETING IN HOT WEATHER

### (1) General

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all plant and equipment required for this purpose

In the event that conditions become such that even with the use of equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

### (2) Concrete Placing in Hot Weather

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the works does not exceed 30°C and that the concrete does not lose any moisture during transporting and placing.

Such measures may include but are not necessarily limited to the following:

- (a) Shielding aggregates from direct sunshine.
- (b) Use of a mist water spray on aggregates.
- (c) Sun shields on mixing plants and transporting equipment.

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Surfaces in which concrete is to be placed shall be shielded from direct sunshine and surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

### 812 CONSTRUCTION JOINTS

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the sections shall be deemed a construction joint.

Where construction joints are shown in the Drawing, the Contractor shall form such joints in such positions. The locations of joints, which the Contractor requires to make for the purpose of construction, shall be subject to the approval of the Engineer. Construction joints shall be in vertical or horizontal planes except in sloping slabs where they shall be normal to the exposed surface or elsewhere where the Drawing require a different arrangement.

Construction joints shall be arranged as to reduce to a minimum the effects of shrinkage in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints.

Feather edges of concrete at joints shall be avoided. Any feather edges which may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The intersections of horizontal and near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the formwork at the top of the concrete lift, or by other means acceptable to the Engineer.

Construction joints formed as free surfaces shall not exceed a slope of 20 per cent from the horizontal.

The surface of the fresh concrete in horizontal or near horizontal joints shall be thoroughly cleaned and roughened by means of high pressure water, and air jets or wire brush, when the concrete is hard enough to withstand the treatment without the leaching of cement. The surface of vertical or near vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time.

Where concrete has become too hard for the above treatment to be successful, the surface whether formed or free shall be thoroughly scabbled by mechanical means, manually or wet sand blasted and then washed with clean water. The indentations produced by scabbling shall not be less than 10 mm deep and shall be away from the finished face by 40 mm.

If instructed by the Engineer the surface of the concrete shall be thoroughly brushed with a thin layer of mortar composed of one part of cement to two parts of sand by weight and complying with Sub-clause 602(2) immediately prior to the deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

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No mortar or concrete shall be placed until the joint has been inspected and approved by the Engineer.

### 813 RECORDS OF CONCRETE PLACING

Records of the details of every pour of concrete placed in the works shall be kept by the Contractor in a form agreed by the Engineer. These records shall include class of concrete, location of pour, date and duration of pour, ambient temperature and concrete temperature at time of placing and all relevant meteorological information such as rain, wind etc., moisture contents of the aggregates, details of mixes batch numbers, cement batch number, results of all tests undertaken, part of the structure and place where test cube samples are taken from.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceding week. In addition, he shall supply to the Engineer monthly histograms of all 28 day cubes strength results together with cumulative and monthly standard deviations, Coefficient of Variation, and any other information which the Engineer may require concerning the concrete placed in the works.

### 814 PLUM CONCRETE

#### (1) Materials

The size of the stone/rock shall not be larger than 200 mm measured in any direction. Concrete to be used in plum concrete shall be as specified in contract document.

#### (2) Construction

Composition of the plum concrete shall be 60 to 70 % M10 or M15 concrete and 40 to 30 % of stones by volume as specified in the contract document. The place to be filled up with the plum concrete shall be cleaned and chipped for adhesion with the concrete. Following completion of form work, a layer of concrete minimum 100 mm thick shall be laid upon over which clean and moist stones shall be placed at a distance of min 100 mm measured from face to face in any direction. The distance between the outer edge of the concrete mass and the nearest face of the stone to the edge shall not be less than 100 mm.

Then another layer of concrete having thickness not less than 100 mm measured from the top of the stone to the top surface of the layer shall be laid and compacted.

In case the proportion of concrete to stones is to be changed, the clear space between stones shall be adjusted as directed by the Engineer.

After compaction, again stones shall be placed on the layer as described above and the process shall be continued until the top layer of the concrete is completed. The placing of stones shall be staggered both in horizontal and vertical directions.

#### (3) Tests and Standard of Acceptance

Stones shall be tested for specific gravity and water absorption test. The test result shall meet the requirements as specified in these Specifications.

Concrete shall be tested as specified in Section 800.

**815 REINFORCEMENT**

**(1) General**

Reinforcement as plain bars and deformed bars and steel fabric shall comply with the following Standards.

NS: 191/ IS: 1786 for high strength deformed steel bars and wires.

IS: 1566 for steel mesh fabric.

NS: 84/ IS: 432 mild steel and medium tensile steel bars.

All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit the ISI certification mark or other test certificate from the manufacturer acceptable to the Engineer.

The sampling and frequency of testing shall be as set out in the NS: 84 and NS: 191.

All reinforcement not complying with the Specification shall be removed from site.

**(2) Storage of Reinforcement**

All reinforcement shall be delivered to site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall either be removed from site or may be tested for compliance with the appropriate Indian Standard in accordance with Sub-clause 814 (1) at the Contractor expense.

Reinforcement shall be stored at least 150 mm above the ground on clean area free of mud and dirt and sorted out according to category, quality and diameter.

**(3) Bending Reinforcement**

Unless otherwise shown on the Drawing, bending and cutting shall comply with IS: 2502.

The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the Drawing.

Bars shall be bent mechanically using appropriate bar benders. Bars shall be bent cold by the application of slow steady pressure. At temperature below 5°C the rate of bending shall be reduced if necessary to prevent fracture in the steel. Bending reinforcement inside the forms shall not be permitted except for mild steel bars of diameter less or equal to 12 mm, when it is absolutely necessary.

After bending, bars shall be securely tied together in boundless or groups and legibly labelled as set out in IS: 2502.

**(4) Fixing Reinforcement**

Reinforcement shall be thoroughly cleaned. All dirt, scale, loose rust, oil and other contaminants shall be removed before placing it in position. If the reinforcement is contaminated with concrete from previous operation, it shall be cleaned before concreting in that section.

Reinforcement shall be securely placed and fixed in position as shown in the drawing or directed by the Engineer.

Unless otherwise agreed by the Engineer, all intersecting bars shall be either tied together with not less than 1.6 mm diameter soft annealed iron wire and the end of the wire turned into the body of the concrete, or shall be secured with a wire clip of a type agreed by the Engineer.

Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Engineer. They shall be made of mortar mixed in the proportions of one part of cement to two parts of sand by weight. Wires cast into the block for tying in to the reinforcement shall have not less than 1.6 mm diameter and shall be soft annealed iron.

Alternatively, another type of spacer block may be used subjected to the Engineer's approval.

All reinforcement shall be checked of shape, size, diameter and number where necessary. Reinforcement shall be rigidly fixed so that it remain intact during placing of concrete. Any fixers made to the formwork shall not remain within the space to be occupied by the concrete being placed.

No splices shall be made in the reinforcement except where shown on the Drawing or agreed by the Engineer. Splice lengths shall be as shown on the Drawing or directed by the Engineer.

Reinforcement shall not be welded except where required by the contract or agreed by the Engineer. If welding is employed, all welded splices shall be full penetration butt welds complying with the procedures set out in IS: 2751 or IS: 9417 as applicable. Mechanical splices shall not be used unless the Engineer agrees otherwise. Acceptance for welded or mechanical splices of approved design shall be based on qualification tests to be carried out by the Contractor prior to start of the work. Construction control testing as instructed by the Engineer shall be also carried out.

The Contractor shall ensure that reinforcement left exposed in the works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars of six times the bar diameter for high yield bars. Such bends shall be carefully straightened without leaving residual kinks or damaging the concrete round them before concrete placing. In no circumstances heating and bending of high yield bars shall be permitted.

Bars complying with IS: 1786 or other high tensile bars shall not be bent after placing in the works.



  
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**816 CONCRETE FOR SECONDARY PURPOSES**

**(1) Non-structural Concrete**

Non-structural concrete (NS concrete) shall be used only for non-structural purposes where shown on the Drawing.

NS concrete shall be compound of ordinary Portland cement and aggregate complying with this Specification.

The weight of cement mixed with 0.3 cubic metres of combined aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand in accordance with Sub-clause 815 (3) to a uniform color and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand towels or rammers or by mechanical vibration.

**(2) No Fines Concrete**

No fines concrete (NF concrete) is intended for use where a porous concrete is required and shall only be used where shown on the Drawing or instructed by the Engineer.

The mix shall consist of Ordinary Portland cement and aggregate complying with this Specification. The aggregate size shall be 40 mm to 10 mm only. The weight of cement mixed with 0.3 cubic metres of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

**(3) Hand Mixed Concrete**

Concrete for structural purposes shall not be mixed by hand. Where non-structural concrete is required, hand mixing may be carried out subject to approval of the Engineer.

For making hand mixed concrete, cement sand and aggregate shall be batched separately by volume or by weight as applicable. Then cement and sand shall be mixed dry to uniform colour. The aggregate shall be stacked in a proper shape upon which cement sand mix shall be spread and whole mix shall be turned up and down to have uniform mix of all ingredients. Then water shall be added as specified in Sub-clause 815 (1) and shall be mixed to uniform consistency.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.25 cubic meter shall be mixed at one time. During windy weather precautions shall be taken to prevent cement from being blown away in the process of gauging and mixing.

**8117 EARLY LOADING**

No load shall be applied to any part of a structure until the specified curing period has expired, and thereafter loading shall be allowed after approval by the Engineer. The Engineer's decision shall be based on the type of load to be applied, the age of concrete, the magnitude of stress induced and the propping of the structure.

No structure shall be opened to traffic until test cubes have attained the specified minimum 28 days' strength as defined in Clause 804.

**818 TEST AND STANDARD OF ACCEPTANCE**

**(1) General:**

Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components.

Random sampling and lot by lot of acceptance inspection shall be made for the 28 days' cube strength of concrete.

Concrete under acceptance shall be notionally divided into lots for the purpose of sampling, before commencement of work. The basis of delimitation of lots shall be as follows;

- i. No individual lot shall more than 30 cu.m. in volume
- ii. Different grades of mixes of concrete shall be divided into separate lots
- iii. Concrete of a lot shall be used in the same identifiable component of the structure

**(2). Sampling and testing**

Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction, according to procedure laid down in IS: 1199.

A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes 150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS: 516. The 28-day test strength result for each cube shall form an item of the sample. Test at other age also shall also be performed, if specified.

Where automated batching plant/ Ready Mixed Concrete Plant is located away from the place of use and the time gap between production and placement is more than initial setting time or where any ingredients are added subsequent to mixing, separate set of samples shall be collected and tested at batching plant and at location of placement. The results shall be compared and used to make suitable adjustment at batching plants so that properties of concrete at placement are as per the requirements.

**(3) Test specimen and sample strength:**

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes maybe required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

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The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than  $\pm 15$  per cent of the average. If variation is more, the test results of the sample are invalid.

The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 8.8.

**Table 8.8: Control Test and their Minimum Frequency for Road and Bridge**

S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
1	<u>PIPE DRAINS, PIPE CULVERTS AND CONCRETE CHANNELS</u>	700	IDENTIFICATION : Gradation, Plasticity Index, CBR In-Situ, Density (95% MDD)	As specified or required by the Engineer
	MATERIALS FOR RE- FILLING THE TRENCHES	701		
2	<u>PRODUCTION OF MATERIALS</u>  NATURAL AND CRUSHED MATERIALS	800	<ul style="list-style-type: none"> <li>Site Trials:</li> <li>Other tests on materials</li> </ul>	<ul style="list-style-type: none"> <li>Before starting production</li> <li>According to the relevant component of the works</li> </ul>
3	<u>EARTHWORKS</u>  FILL MATERIAL	900	<ul style="list-style-type: none"> <li>Material Identification, MDD, OMC, CBR</li> <li>MC</li> </ul>	<ul style="list-style-type: none"> <li>For each new source and in every 1500 cum or part of it</li> <li>For each new source and in every 400 cum or part of it</li> </ul>
	COMPACTION		<ul style="list-style-type: none"> <li>Field Density</li> </ul>	<ul style="list-style-type: none"> <li>One set[ 3 test] per 1000 sqm of each layer</li> </ul>

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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
8	<p><u>GRADED CRUSHED STONE FOR BASE AND SUBBASE [WET MIX MACADAM]x</u></p> <p>MATERIAL</p> <p>COMPACTION</p>	1202	<ul style="list-style-type: none"> <li>Material Identification, MC, Gradation Plasticity index</li> <li>CBR, MDD, OMC, LAA/ AIV, Crushing ratio</li> <li>Field Density</li> </ul>	<ul style="list-style-type: none"> <li>For each new source and in every 200 cum or part of it</li> <li>For each new source and in every 1000 cum or part of it</li> <li>One set of three test per 1000 sqm of each layer</li> </ul>
9	<p><u>GRAVEL WEARING COURSE</u></p> <p>MATERIAL</p> <p>COMPACTION</p>	1205	<ul style="list-style-type: none"> <li>Material Identification,; Gradation, Plasticity index, CBR, LAA/AIV, MDD, OMC</li> <li>Field Density</li> </ul>	<ul style="list-style-type: none"> <li>For each new source and in every 400 cum or part of it</li> <li>One set of three test per 1000 sqm of each layer</li> </ul>
10	<p>BITUMINOUS SURFACE AND BASE COURSE</p> <p>PRIME COAT - TACK COAT MATERIAL</p> <p>CONSTRUCTION</p>	<p>1300</p> <p>1302</p>	<ul style="list-style-type: none"> <li>Quality of Binder as per IS73( paving bitumen)/ IS 217 (Cut back bitumen)/ IS 8887 ( cationic emulsion) ; penetration, Absolute and Kinematic viscosity, flash point, ductility, solubility in Trichloroethylene, Softening point, <b>Tests on residue from rolling thin film oven) Viscosity ratio at 60°C, Ductility:</b></li> <li>Binder temperature for Application</li> <li>Rate of spread of binder</li> </ul>	<ul style="list-style-type: none"> <li>Certificates from suppliers.</li> <li>One set of tests for each 50,000 litres of supply or part of it.</li> <li>At regular close interval</li> <li>Three test per day</li> </ul>

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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
11	<u>SURFACE DRESSING MATERIAL</u>  CONSTRUCTION	1303	<ul style="list-style-type: none"> <li>Quality of binder:</li> <li>LAA/AIV,</li> <li>Flakiness index, Elongation index</li> <li>Stripping value, Water absorption of aggregate</li> <li>Grading of aggregate</li> <li>Rate of application of chippings/ Binder</li> <li>Control temperature of binder in boiler, aggregate in the dryer, mix at the time of laying and rolling</li> </ul>	<ul style="list-style-type: none"> <li>Same as mention under SNo 10</li> <li>For each new source and in every 200 cum or part of it</li> <li>For each new source and in every 100 cum or part of it</li> <li>One test of each source and whenever there is change in the quality of aggregate or source of aggregate.</li> <li>Two test per day/ once per 250 cum</li> <li>Three test per day or 1 test per 5000 sqm</li> <li>At regular close interval</li> </ul>
12	<u>PENETRATION MACADAM (SEMI GROUT) MATERIAL</u>  CONSTRUCTION	1304	<ul style="list-style-type: none"> <li>Quality of binder:</li> <li>LAA/AIV, Gradation</li> <li>Flakiness index</li> <li>Rate of application of chippings/ binder</li> <li>Binder temperature for application</li> </ul>	<ul style="list-style-type: none"> <li>Same as mention under S.No. 10</li> <li>For each new source and in every 200 cum or part of it</li> <li>For each new source and in every 100 cum or part of it.</li> <li>Three test per day or 1 test per 5000 sqm</li> <li>At regular close interval</li> </ul>
13	<u>SAND SEAL MATERIAL</u>  CONSTRUCTION	1305	<ul style="list-style-type: none"> <li>Quality of binder:</li> <li>Gradation, Plasticity index</li> <li>Rate of application of chippings/ binder</li> </ul>	<ul style="list-style-type: none"> <li>Same as mention under SNo 10</li> <li>For each new source and in every 200 cum or part of it</li> <li>Three test per day or 1 test per 5000</li> </ul>



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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
15	<p><u>OPEN GRADED PREMIX SURFACING/ CLOSE GRADED PREMIX SURFACING MATERIAL</u></p> <p>CONSTRUCTION</p>	1310/ 1311	<ul style="list-style-type: none"> <li>Quality of binder:</li> <li>LAA/AIV,</li> <li>Flakiness index, Elongation index</li> <li>Stripping value, Water absorption of aggregate</li> <li>Grading of aggregate</li> <li>Rate of application of chippings/ Binder</li> <li>Control temperature of binder At application</li> </ul>	<ul style="list-style-type: none"> <li>Same as mention under SNo 10</li> <li>For each new source and in every 200 cum or part of it</li> <li>For each new source and in every 100 cum or part of it</li> <li>One test of each source and whenever there is change in the quality of aggregate or source of aggregate.</li> <li>Two test per day/ once per 250 cum</li> <li>Two test per day per plant or 1 test per 5000 sqm</li> <li>At regular close interval</li> </ul>
16	<p><u>SAND ASPHALT MATERIAL</u></p>	1312	<ul style="list-style-type: none"> <li>Quality of binder:</li> <li>LAA/AIV,</li> <li>Sand equivalent, Plasticity Index, stability of mix</li> <li>Mix grading, Binder content</li> </ul>	<ul style="list-style-type: none"> <li>Same as mention under S.No 10</li> <li>For each new source and in every 200 cum or part of it</li> <li>Once test for each source and change in source</li> <li>One set consisting of three for each 400 ton of mix subject to minimum of two test per day per plant</li> </ul>
17	<p><u>BITUMINOUS COLD MIX MATERIAL</u></p>	1313 1314	<ul style="list-style-type: none"> <li>Quality of emulsion ( binder) An ionic Emulsion as per IS 3117 and Cationic as per ; ( viscosity at 25°C, Bitumen content, cement mixing, sieve test, Miscibility with water, <b>Tests on residue etc.</b>)</li> </ul>	<ul style="list-style-type: none"> <li>Certificates from suppliers.</li> <li>One set of tests for each 50,000 litres of supply or part of it.</li> <li>For each new source and in every 200 cum or</li> </ul>

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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
			<ul style="list-style-type: none"> <li>Gradation, Sand equivalent, water absorption, Soundness test ( Sodium/ Magnesium Sulphate test)</li> <li>Quality of filer</li> </ul>	part of it <ul style="list-style-type: none"> <li>One set consisting of three for each 200 ton</li> </ul>
	CONSTRUCTION		<ul style="list-style-type: none"> <li>Rate of spread of Emulsion</li> <li>Rate of spread of mixed material</li> <li>Stability, Flow and voids, Binder content</li> <li>Density of compacted mix layer</li> </ul>	<ul style="list-style-type: none"> <li>One test per 500 sqm and not less than two tests per day</li> <li>Regular control through checks of layer thickness</li> <li>One set consisting of three for each 400 ton of mix subject to minimum of two test per day per plant</li> <li>One test per 250 sqm of area</li> </ul>
18	<u>OTTASEAL MATERIAL</u>  CONSTRUCTION	1316	<ul style="list-style-type: none"> <li>Quality of binder:</li> <li>Flakiness index</li> <li>LAA/AIV, , Elongation index/Stripping value</li> <li>Grading</li> <li>Temperature of binder</li> <li>Rate of Application of Binder</li> </ul>	<ul style="list-style-type: none"> <li>Same as mention under SNo 14</li> <li>One test for each new source and in every 250 cum or part of it</li> <li>One set of 3 specimen for each new source and as directed by the Engineer</li> <li>One test for 50 cum of aggregate</li> <li>At regular close interval</li> <li>Two test per run</li> </ul>
19	<u>CONCRETE MATERIALS</u>	2000	<ul style="list-style-type: none"> <li>Cements: Acceptance tests</li> <li>Control tests: Chemical</li> </ul>	<ul style="list-style-type: none"> <li>Conservative samples for each supply and not less than every 200 t or part of it</li> <li>Testing in case of</li> </ul>

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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
			Composition Physical Properties	noncompliance of the mixes or storage on site for longer than 1 month
			<ul style="list-style-type: none"> <li>• <b>Aggregates:</b> <b>Acceptance tests:</b> <b>CONTROL TESTS:</b> Grading Silt &amp; clay content: Organic Impurities Chloride content, sulphate content, Alkali reactivity, Water, Admixtures</li> <li>• <b>CONCRETE</b> ✓ LAB. TRIALS ✓ SITE TRIALS ✓ CONTROL TESTS ✓ COMPRESSIVE STRENGTHS</li> </ul>	<ul style="list-style-type: none"> <li>• 1 set ( 3 nos ) test for each 10 to 50 cum and additional test for each 50 cum of concrete t for fine aggregate</li> <li>• 1 set ( 3 nos ) test for each 25 to 125 cum and additional test for each 125 cum and 250 t part of it for coarse aggregate</li> <li>• As frequently as Required</li> <li>• Sub-Clause 2004(7) and(8)</li> <li>• Sub-Clause 2004(3)</li> <li>• For 1-5 cum quantity of work at one place 1 set,</li> <li>• For 5.1-15 cum quantity of work at one place 2 set</li> <li>• For 15 .1 to 30 cum quantity of work at one place 3 set</li> <li>• For 30 .1 to 50 cum quantity of work at one place 4 set</li> <li>• For more than 50 cum quantity of work at one place 4 set .of sample plus one additional for each 50 cum or part thereof</li> <li>• Early works every 6 cum or part of it</li> </ul>



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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
			<ul style="list-style-type: none"> <li>• <b>REINFORCEMENT</b> <ul style="list-style-type: none"> <li>✓ Mechanical properties 0.2 percent proof stress/ yield stress,</li> <li>✓ Tensile strength/ yield strength ratio,</li> <li>✓ Elongation</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• For 1-25 bundles lot 3 rod (one from each bundle) from randomly selected 3 bundles.</li> <li>• For 26-65 bundles lot 4 rod ( one from each bundle) from randomly selected 4 bundles</li> <li>• For 66-180 bundles lot 5 rod ( one from each bundle) from randomly selected 5 bundles</li> <li>• For 181- 300 bundles lot 7 rod ( one from each bundle) from randomly selected 7 bundles</li> <li>• For &gt; 300 bundles lot 10 rod ( one from each bundle) from randomly selected 10 bundles</li> </ul>
20	<p><u>MISCELLANEOUS STRUCTURES</u> GABIONS MATERIALS</p>	<p>2400  2401</p>	<ul style="list-style-type: none"> <li>• Gabion wires : Tensile Strength, Mass, Uniformity and adhesion of Zinc coating</li> </ul>	<ul style="list-style-type: none"> <li>• Upto 25 coils two set of sample</li> <li>• 26-50 coils three set of sample</li> <li>• 51-150 coils five set of sample</li> <li>• 151-300 coils eight set of Sample</li> </ul>

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S No	PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
			<ul style="list-style-type: none"> <li>Specific gravity and water absorption of stones</li> </ul>	<ul style="list-style-type: none"> <li>&gt;301 coils thirteen set of sample</li> <li>At least 3 set of tests for every source of material</li> </ul>
	CRIB WALLS	2402	<ul style="list-style-type: none"> <li>Gradating of backfill materials</li> </ul>	<ul style="list-style-type: none"> <li>Minimum one test for every 250 cum or part of it and for each source of material</li> </ul>
	SUB-SURFACE DRAINS	2404	<ul style="list-style-type: none"> <li>Gradation Analysis</li> </ul>	<ul style="list-style-type: none"> <li>One set of test for every 50 cum and or part of it and for each change in source of material</li> </ul>
21	<u>BRICK WORK FOR STRUCTURES MATERIALS</u>  MORTAR	2502  2511	<ul style="list-style-type: none"> <li>Quality of Bricks</li> <li>Quality of cement and sand</li> <li>Control tests</li> <li>Compressive strength of mortar</li> </ul>	<ul style="list-style-type: none"> <li>As required</li> <li>Every 10 cum of brick work or part of it.</li> </ul>
22	MASONRY FOR STRUCTURES MATERIALS  MORTAR	2602  2610	<ul style="list-style-type: none"> <li>Quality of cement and sand</li> <li>Control tests</li> <li>Compressive strength of mortar</li> </ul>	<ul style="list-style-type: none"> <li>As required</li> <li>Every 10 cum of masonry of part of it</li> </ul>

**(4) Acceptance criteria**  
**(a) Compressive Strength**

**I Cubes**

The concrete shall be taken as having the specified compressive strength when both the following conditions are met:

- i. The mean strength determined from any group of four consecutive non-overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.
- ii. Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches

## II Cores

When the concrete does not satisfy both the condition given in I above, representative cores shall be extracted from the hardened concrete for compression test in accordance with the method described in IS: 1199 and tested to establish whether the concrete satisfies the requirement of compressive strength.

Evaluation of compressive strength by taking cores may also be done in case of doubt regarding the grade of concrete used either due to poor workmanship or based on result of cube strength tests the locations from which core samples are to be taken and their number shall be decided so as to be representative of the whole of the concrete under consideration. However, in no case shall fewer than three cores be tested. Cores shall be prepared and tested as described in IS: 516. Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has strength less than 75 percent of the specified strength.

### (b) Chloride and Sulphate Content

Where Chloride and Sulphate is specified, the total chloride and sulphuric anhydride (SO<sub>3</sub>) content of all the constituents of concrete as a percentage of mass of cement in the mix shall not exceed the values given in this Section of the specifications.

### (c) Density of Fresh Concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

### (d) Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive non – overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

### (e) Permeability Test

Where Permeability of concrete is specified, water Permeability test as per DIN: 1048 Part 5 – 1991 shall be carried out as described below

- i. A cylindrical test specimen 150 mm dia and 160 mm high shall be prepared.
- ii. After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that the specimen can be subjected to a water pressure upto 7 bars.
- iii. The concrete specimen shall be subjected to a water pressure of 0.5 N/mm<sup>2</sup> from the top for the period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and the specimen

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rejected as fail.

- iv. After 3 days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.
- v. When the split faces show signs of drying (after 5 to 10 minutes) the maximum depth of penetration in the direction of height shall be measured with the scale and extent of water penetration established.
- vi. The mean of maximum depth of penetration obtained from three specimens thus tested, shall be taken as the test result and it shall not exceed 25 mm

If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. Any additional work required by the Engineer for such acceptance shall be carried out by the Contractor at his cost. In such case payment for such work shall be made at reduced rate proportional to reduced strength rate. In case the concrete is not found to be acceptable even after investigation, the Contractor shall remove the rejected concrete forthwith.

**819. WATER PROOFING AND ASPHALT APPLICATION**

**A. FIBRE REINFORCED ELASTOMERIC LIQUID WATER PROOFING MEMBRANE WITH RESILIENT ACRYLIC POLYMERS**

**(1) Material**

Fiber reinforced elastomeric liquid water proofing membrane is a ready-to-use waterproofing, white product, with high solar reflectance and Sun Reflectivity Index (SRI) of 105, for external applications. This is made from resilient acrylic polymers and synthetic resins in water dispersion, and when dry forms a continuous, flexible waterproofing membrane. This is resistant to all atmospheric conditions and UV rays, and guarantees long lasting protection for the substrate.

**(2) Technical Specification/ Parameters**

1. Fiber reinforced elastomeric liquid water proofing membrane with fibers in water emulsion with high reflectance and emissivity with a solar reflectance index SRI of 105 should comply with the requirements of EN 1504-9 ("Products and systems for protecting and repairing concrete structures: definitions, requirements, quality control and conformity assessment. General principles for the use of products and systems") EN 1504-2 coating (C) principles PI, MC and IR ("Concrete surface protection systems").
2. This should possess a paste like consistency having highly reflective white color.
3. This should have density of 1.35 with dry solid content of 61.4%.
4. This should have minimum tensile strength of 1.0N/mm<sup>2</sup> as per ISO 37 or ASTM D-412.
5. This should confirm to results after testing as per EN1062-11 for exposure to artificial weather conditions.
6. The Sun Reflectivity Index when tested as per ASTM E1980 should be 105 minimum.
7. Elongation at break (% age) of 150 % minimum as per ASTM D-412.
8. Adhesion strength is more than 1.0 N/mm<sup>2</sup> as per ASTM D-4541.

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### (3) Applications

It is to be applied using a long-haired roller, brush or spray on any horizontal, sloping or vertical surfaces to form a string, flexible, tack-free dry surface, suitable for occasional light foot traffic. This can withstand normal expansion and contraction stresses caused by temperature variations due to its flexibility. This also helps lower the working temperature of roofs and guarantees good energy performance properties of all the layers of the roof.

### (4) Preparation of Surface

All the substrates, whether they are new or old, must be sound, clean, dry and free of all traces of oil, grease, old paint, rust, mould and any other material which could compromise the bond. Application temperature may be from 70C to 400C.

Concrete and in general mineral substrates must be sound and dry with no rising damp. Any loose parts must be removed with wire brushes. All wax, water-repellent treatments, etc. must be removed from the surface of ceramic substrates with a suitable detergent and/ or by sanding. Any hollows and gaps in the surface must be repaired properly with appropriate material as described and instructed by the manufacturer of this product. The tools to be used must be properly cleaned.

### (5) Application Procedure, Measurement and Payment

All the area of operation shall be thoroughly cleaned. Mix the content in such a manner that they are perfectly blended into a homogenous state of liquid which can be applied by long haired roller or airless spray. The fibre reinforced elastomeric liquid water proofing membrane with resilient acrylic polymers shall be applied on top of concrete roof in three coats @ 10.76 litre/10 sqm or more as recommended by manufacturer specification. One coat i.e. first coat of self-priming elastomeric water proofing liquid. The material shall be diluted with water in the ratio of 3:1 (3 parts of elastomeric water proofing liquid and 1 part of water). Wait until the first coat is completely dry and becomes slightly darker in colour. After the first coat has dried completely apply second coat with undiluted elastomeric water proofing liquid in a cross direction to the previous coat. After the drying of second coat completely apply the final coat of undiluted elastomeric water proofing liquid in a direction perpendicular to previous coat. The overall dry film thickness should not be less than 500 microns or more as specified in manufacturer specification. Protect the membrane from rain unless it is completely dry. The overall consumption of the material should be as per nomenclature of the item and should also adhere to the specifications detailed in the approved schedule of the manufacturer.

#### Measurement and Payment

The length and breadth/ height shall be measured in running meter correct to two places of decimal and the area of applications should be measured in sqm correct to two places of decimal. The unit of measurement of area of application shall be square meter unless otherwise specified.

The unit rate shall include the cost of all the labour and material involved in all the operations described above. The payment shall be made as per unit rate specified in BoQ.

## B. APPLICATION OF ASPHALT

### (1) General

Asphalt provides excellent waterproofing, preventing leaks and protecting the underlying structure from moisture damage. It withstands various weather conditions, including rain, snow, and UV exposure, contributing to a long lifespan for roofs. Asphalt can accommodate

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

temperature fluctuations and structural movement, reducing the risk of cracking. Asphalt to be used for roofing should be of high quality to provide excellent water proofing and good bonding.

### (2) Melting of Asphalt

Asphalt melting refers to the process of heating asphalt to transform it from a solid to a liquid state, making it easier to work with for applications such as roofing, paving, and maintenance. Asphalt typically melts at temperatures between 250°F and 350°F (121°C to 177°C), depending on the specific type and formulation. Asphalt can be melted using direct heating or indirect heating as follows:

**Direct Heating:** Using a flame or hot air to melt the asphalt. This method requires careful control to avoid overheating.

**Indirect Heating:** Using heated equipment, like tanks or kettles, to warm the asphalt without direct flame exposure.

### (3) Application

Melted asphalt is common in the installation of asphalt-based roofing systems, allowing for proper adhesion of materials. It is also used in patching and sealing cracks in existing surfaces.

### (4) Measurement and Payment

The length and breadth shall be measured in running meter correct to two places of decimal and the area of applications should be measured in sqm correct to two places of decimal. The unit of measurement of area of application shall be square meter unless otherwise specified.

The unit rate shall include the cost of all the labour and material involved in all the operations described above. The payment shall be made as per unit rate specified in BoQ.

## 820 MEASUREMENT

### (1) Concrete

Concrete laid in place as specified in the Drawing or directed by the Engineer shall be measured in cubic metres separately for each class. No deduction shall be made in the measurement for:

- (a) bolt holes, pockets, box outs and cast in components provided that the volume of each is less than 0.15 cubic metres;
- (b) mortar beds, fillets, drips, rebates, recesses, grooves, chamfers and the like of 100 mm total width or less;
- (c) reinforcement

### (2) Blinding Concrete/Non Structural Concrete

Blinding concrete laid in place shall be measured in cubic meter. No deduction shall be made for openings provided that the area of each is less than 0.5 square metres. Blinding concrete over hard material shall be measured as the volume used provided that the maximum thickness of 150 mm allowed for over break in not exceeded.

### (3) Admixtures, Workability and Hardening Agents and Curing Compounds

Unless stated otherwise, rate of concrete shall deemed to include admixture, workability, hardening agent and curing compounds.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

### (4) Plum Concrete

Unless specified otherwise plum Concrete shall be measured in cu.m. Form work struts, bracing supports etc. shall be measured separately as it is not deemed to be included in the measurement of plum concrete.

### (5) Reinforcement

All types of reinforcement shall be measured in length including hooks, if any, separately for different diameters as actually used in works or as directed by the Engineer, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in ton on the basis of IS: 1732.

Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other method for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

An average weight of at least 5 samples each one metre length shall be determined by the laboratory approved by the Engineer. The weight of each type of the reinforcement shall be determined by multiplying average weight of the respective reinforcement by its length.

### (6) Fabric Reinforcement

Fabric reinforcement laid as per Drawing or as directed by the Engineer shall be measured in square meter. No allowance shall be made for laps and wastage.

## 821 PAYMENT

### (1) Concrete

Every class of concrete shall be paid as per respective contract unit rate. In addition to those specified in Clause 112 the respective rate shall also include the cost of:

- (a) All materials including admixture and workability agent, curing agent, labour, Tools, Plants and equipment required for mixing, transporting and placing in position, vibrating and compacting, finishing and curing including all incidental expenses.
- (b) Unless mentioned separately as an item in contract sampling and testing, quality assurance and supervision
- (c) Unless mentioned separately as an item in contract, cost of providing, fixing, and removing formwork, Staging required for concrete work as per Section 1800 of these specification.
- (d) Placing and compacting against excavated surfaces where required including any additional concrete to fill over break and working space.
- (e) Complying with the requirements of Clauses 801 to 813.

### (2) Plum Concrete

Plum concrete shall be paid as per contract unit rate of the respective item which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the works as per these Specifications.

STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

**(3) Reinforcement**

The reinforcement shall be paid at contract unit rate. In addition to those specified in Clause 112 the rate shall also include compensation for the cost of providing, cutting to length, splice lengths additional to those shown on the Drawing, laps, bending, hooking, waste incurred by cutting, cleaning, spacer blocks, provision and fixing of chairs or other types of support, welding, fixing the reinforcement in position including the provision of wire or other material for supporting and tying the reinforcement in place, bending reinforcement aside temporarily, and straightening, place and compacting concrete around reinforcement and for complying with Clause 814.

**(4) Fabric Reinforcement**

The fabric reinforcement shall be paid at contract unit rate which shall be also inclusive of compensation for wastage and laps.



STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

**SECTION 900: FORMWORK**

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Secretary

## SECTION 900: ROOFWORK

### 901 SCOPE AND DEFINITIONS

This Section covers the preparation, construction and removal of formwork in general and false work in some special case for concrete structures. It also covers the quality requirements for surface finish on formed and unformed surfaces.

Definitions used in this Clause and other relevant Clause of this Section and other relevant Sections of these Specifications are as follows:

- Formwork means the surface against which concrete is placed to form a face. All the immediate support necessary to retain the surface in position while concrete is placed, shall be treated an integral part of formwork.
- False work means the structural elements supporting both the formwork and the concrete until the concrete becomes self-supporting.
- A formed face is one which has been cast against formwork.
- An unformed surface means a horizontal or nearly horizontal surface which is not cast against form work.
- An exposed face is one which will remain visible when construction has been completed.

### 902 GENERAL

The Contractor shall be responsible for designing and construction of formwork and false work so that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic, and so that after the concrete has hardened the formed faces shall be in the positions shown on the Drawing within the tolerances set out in Clause 905.

Before construction begins, the Contractor shall submit to the Engineer Drawing showing details of the proposed formwork and false work as the case may be in accordance with this Section and other relevant Section of these Specification.

### 903 FORMWORK FOR CONCRETE

#### (1) Construction of Formwork

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous in a regular pattern.

All joints in formwork shall be water tight. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position, if required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

Surfaces at slopes less than  $20^\circ$  may be formed by screeding. Surfaces at slopes between  $20^\circ$  and  $30^\circ$  shall generally be formed if the Contractor can demonstrate to the satisfaction of the Engineer that such slopes can be screeded with the use of special screed boards to hold the concrete in place during vibration.

Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork shall also be tied down or otherwise secured against floating within the body of the concrete.

The internal and external angles on concrete surfaces shall be formed with fillets and chamfers of the sizes shown on the Drawing unless otherwise instructed by the Engineer.

Supports for formwork may be bolted to previous placed concrete provided the type of bolt used is acceptable to the Engineer. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be close to the face of the concrete by less than 50 mm.

Formwork shall not be re-used after it has suffered damage as it will impair the finished surfaces of the concrete. Where circumstances prevent easy access within the form, temporary openings shall be provided through the formwork for cleaning and inspection.

Shear keys of the size and shape as indicated on the Drawing shall be provided in all construction joints.

Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Engineer, they shall comply with the requirements of formwork as specified in the Specification in respect of surface finish, strength and rigidity. Such elements shall be set true to line and level within the tolerances prescribed for the appropriate class of finish in Clause 906 and fixed so that they cannot move when concrete is placed against them.

### (2) Preparation of Formwork

Before any reinforcement is placed into position within formwork, the formwork shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either a suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or a low viscosity oil containing chemical agents. The Contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining or discoloration of the concrete, air holes on the concrete surface, or retards the set of the concrete or affects the strength of concrete.

In order to avoid colour differences on adjacent concrete surfaces, only one type of release agent shall be used in any one section of the works.

In cases where it is necessary to fix reinforcement before placing formwork, all surface preparation of formwork shall be carried out before it is placed into position. The Contractor shall not allow reinforcement or pre-stressing tendons to be contaminated with formwork release agent.

Before placing concrete all dirt, construction debris and other foreign matter shall be removed completely from within the placing area.

Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs. If any movement noticed, the formwork shall be set right immediately.

**(3) Removal of Formwork**

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand any stresses safely to which it may thereby be subjected.

The minimum periods which shall elapse between completion of placing concrete and removal of forms are given in Table 9.1 and apply to ambient temperatures higher than 10oC. At lower temperatures or if cement other than ordinary Portland are involved, the Engineer may instruct longer periods.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 9.1, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

Compliance with these requirements shall not relieve the Contractor of his obligation to delay removal of formwork until the removal can be completed without damage to the concrete.

If the Contractor wishes to strip formwork from the underside of arches, beams and slabs before the expiry of the period for supports set out above, it shall be designed so that it can be removed without disturbing the supports. The Contractor shall not remove supports temporarily for the purpose of stripping formwork and subsequently replace them.

As soon as the formwork has been removed, bolt holes in concrete faces other than construction joints which are not required for subsequent operations shall be completely filled with mortar sufficiently dry to prevent any slumping at the face. The mortar shall be mixed in the same proportions as the fine aggregate and cement in the surrounding concrete and with the same materials and shall be finished flush with the face of the concrete.

After laying of the formwork and casting of concrete thereby, the date of casting of concrete shall be marked on the surface of related concrete by water proof paint/marker for estimation of curing time and removal time of formwork.

**Table 9.1: Minimum Periods for Formwork Removal**

Position of Formwork	Minimum period for Temperatures over 10o C	Strength to be attained
Vertical or near vertical faces of mass Concrete	24 hours	0.2 $f_{ck}$
Vertical or near vertical faces of reinforced	48 hours	0.3 $f_{ck}$
Underside of arches beams and slabs (formwork only)	4 days	0.5 $f_{ck}$
Supports to underside of arches, beams and slabs	14 days	$f_{ck}$
Arched linings in tunnels and underground works	24 hours	4 N/mm <sup>2</sup>

*Note:  $f_{ck}$  is the Characteristic Strength for the class of concrete used.*

## 904 FALSEWORK

### (1) Design and Drawing

The design of all false work for structures with span lengths of 6 meters or more and the design of all false work where traffic openings are specified shall conform to the requirements of this Clause.

Detailed working drawing in triplicate and design calculations for false work shall be furnished by the Contractor to the Engineer.

No false work construction shall start until the Engineer has reviewed and approved the Drawing. The Contractor shall provide sufficient time for the Engineer to complete this review.

Such time shall be proportionate to the complexity of the false work design and in no case shall be less than two weeks. The Contractor may revise the false work drawing at any time provided sufficient time is allowed for the Engineer's review and approval, before construction is started on the revised portion.

#### (a) False work Drawing

The false work drawing shall include but not limited to the following: -

- (i) The traffic openings.
- (ii) A superstructure placing diagram, showing proposed concrete placing sequence and construction joints location.
- (iii) Assumed values of soil bearing capacity for both wet and dry conditions, as determined by the Contractor.
- (iv) Anticipated total settlements of false work and forms.
- (v) Details of drainage, if any.
- (vi) Details of drainage protection (or scouring/undermining protection) of footing and/or foundations, including locations of existing utilities, excavations, recent fills if any.
- (vii) Details of all elements required to insure the free movements of concrete due to shrinkage.

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- (viii) Proposed cambers to compensate deflections, and false adjustments according to the various stages of the construction and the concrete placing sequence.
- (ix) Details of joints, bracing and major arrangements to insure vertical and horizontal stability in all direction and at all stages of operations.
- (x) Manufacture's recommendations and/or other operating recommendations as required for the justifications for the design.

When a schedule for placing concrete is shown on the contract plans, no deviation shall be permitted there from unless approved in writing by the Engineer.

Anticipated total settlement shall not exceed 25 mm. This shall include false work footing settlement and joints take-up. Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.

### (b) False work Calculation

The calculations must show the stresses & deflections of all supporting members. The design of false work shall be based upon the maximum loads, the maximum stresses and deflections and the conditions listed below. The stresses listed are based upon the use of undamaged high quality materials and such stresses shall be reduced by the Contractor if lesser quality materials are to be used. The Contractor shall be responsible for the proper evaluation of his false work material and design of false work to carry safely the actual loads imposed.

- (i) The design loads for false work shall consist of the sum of dead and live vertical
- (ii) Loads and horizontal load.
- (iii) The vertical design loads for the combined live and dead loads shall not be less than the actual required loads with due allowance for dynamic loads. However, it shall not be less than 0.5 t/m<sup>2</sup>.
- (iv) Dead load shall include the weight of concrete, reinforcing steel, forms and false work.
- (v) Live load shall consist of the actual weight of the equipment to be supported by false work, applied as concentrated loads, at the points of contact and a uniform of and less than 0.1 t/m<sup>2</sup> applied over the area supported, plus 0.11t/lm applied at the outside edges of deck overhangs.
- (vi) The horizontal loads to be resisted in any direction by diagonal bracing, ties or other means approved by the Engineer shall not be less than 2 percent of the total dead load.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

- (vii) False work footing shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing capacity and anticipated settlements.
- (viii) If the concrete is to be pre stressed, the false work shall be designed to support increased or readjusted loads caused by the pre stressing forces.
- (ix) Joists supporting slabs and overhangs shall be considered as false work and they shall be designed for the maximum loading and deflections loading and deflections permissible on jacks, brackets, columns joist and other manufactures devices shall not exceed the manufacturer's recommendations and in all cases their deflections shall be less than 1/270 of their clear span.

If requested by the Engineer, the Contractor shall furnish catalogue data listing the manufacturer's recommendations for manufactured devices and perform tests as necessary to demonstrate the adequacy of any such device proposed for use.

False work designed for pre-stressed concrete shall allow for the required free movements during pre-stressing operations.

When footing foundations are to be used, the bearing capacity of the soils shall be determined by the Contractor using the Plate Load Test method. The soil surface must be prepared adequately to allow for a relevant implementation of this test. Tests shall be carried out in both dry and wet conditions.

### (c) False work over or Adjacent to Roadways

In addition to the minimum requirements specified above, false work over or adjacent to roadways, where false work opening is specified, shall be designed and constructed so that the false work will be stable if subjected to impact by vehicles. The false work design in such cases shall include, but not be limited to the following minimum provisions:

- (i) The vertical design load of false work bents, including footing and caps which support the portion of the false work over openings shall be increased to not less than twice the design load calculated in accordance with Sub-Clause 904 (1) (b).
- (ii) Each false work post adjacent to openings shall be securely anchored to its withstand footing or otherwise laterally restrained at its base so as to withstand a 0.9t force applied at the base of the post in any direction except toward the road track.

### (2) Construction

The false work shall be constructed to substantially conform to the false work Drawing. The materials used in the false work construction shall be of the quality necessary to sustain the stresses required by the false work design.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

The workmanship used in false work construction shall be of such quality that the false work will support the loads imposed on it without excessive settlement to take-up beyond that shown on the false work Drawing. False work shall be founded on a solid footing safe against undermining protected under softening, and capable of supporting the loads imposed on it. When false work is supported on piles, the piles shall be driven to a bearing value determined in accordance with IS 2911.

When false work is over or adjacent to roadways or waterways, all details of the false work system which contribute to horizontal stability and resistance to impact shall be installed at the time each element of the false work is erected and shall remain until the false work is removed.

Suitable jacks or wedges shall be used in connection with false work to set the forms at the required grade and to take up excessive settlement in the false work either before or during the placing of concrete.

Comber strip shall be used as approved by the Engineer, to compensate the false work deflection, vertical alignment and anticipated structure deflection. The Contractor shall provide tell-tales attached to the soffit and readable from the ground, in enough systematically placed locations to determine the total settlement of the entire portion the structure where the concrete is being placed.

Should unanticipated events occur, including settlements that deviate more than plus or minus 10 mm from those indicated on the false work Drawing, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirements of this Specification, the placing of concrete shall be discontinued until corrective measures satisfactory to the Engineer are provide. In the event satisfactory measures are not provided prior to the initial set of the concrete in the affected area, the placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed.

The Contractor shall be responsible for the maintenance of false work throughout the construction.

### (3) Removal

False work shall not be released before the requirements of Sub-clause 903 (3) are fulfilled. False work for cast-in-situ pre-stressed concrete shall be released according to the pre-stressing sequences shown on the Drawing. False work shall be removed uniformly and gradually to permit the structure to take its load slowly and evenly.

All false work material shall be removed. False work pilling shall be removed up to at least 600 mm below the surface of the original ground or the bottom or side slope of excavated areas.

### (4) False work for Steel Structures

False work for steel structures shall comply with the requirements of Sub-clause 904(1) to 904 (4) in addition to the requirements of this Sub-clause.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

False work and forms shall be constructed so that any loads applied to girder webs shall be applied within a distance to a flange or stiffener approved by the Engineer and shall be distributed in a manner that will not produce local distortion of the web.

Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and prevent appreciable relative vertical movement between the edge of deck forms and the adjacent steel girder.

### 905 SURFACE FINISH ON FORMED SURFACES

#### Class of Finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawing and are defined hereunder: -

#### (1) Class F1 Finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet metal or any other suitable material which will prevent the loss of laitance from the concrete being placed.

#### (2) Class F2 Finish

This finish is for surfaces which are permanently exposed to view but the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thicknesses tongued and grooved boards with square edges arranged in uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them.

Joints between boards or panels shall be horizontal and vertical unless otherwise directed. In this type of finish pitting, fins surface discoloration and other minor defects shall be remedied at the time and by methods agreed by the Engineer.

#### (3) Class F3 Finish

This is for surfaces which will be in contact with water flowing at high velocity, and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved uniform pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features or changes in direction of the surfaces.

All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

**(4) Curved Surfaces**

For curved surfaces where F2 or F3 finishes are called for, the formwork face shall be built up of splines cut to make a tight surface which shall then be dressed to produce the required finish.

Alternatively, single curvature surfaces may be faced with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush. Linings shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

**(5) Tolerances**

All parts of formed concrete surfaces shall be in the positions shown on the Drawing within the tolerances set out in Table 9.2.

In cases where the Drawing call for tolerances other than those given in Table 9.2 the Drawing shall rule.

Where precast units have been set to a specified tolerance, further adjustments shall be made as necessary to produce a satisfactory straight or curved line. When the Engineer has approved the alignment, the Contractor shall fix the units so that there is no possibility of further movement.

**Table 9.2: Tolerances**

Class of finish	Tolerances in mm (See Note)		
	A	B	C
F1	10	10	+25 to - 10
F2	5	10	±15
F3	2	5	±10

*Note: The tolerances A, B and C given in the table are defined as follows:*

- A Is an abrupt irregularity in the surface due to misaligned formwork or defects in the face of the formwork
- B Is gradual deviation from a plane surface as indicated by a straight edge 3 m long. In the case of curved surfaces, the straight edge shall be replaced by a correctly shaped template.
- C Is the amount by which the whole or part of a concrete face is displaced from the correct positions shown on the Drawing

**906 FINISHES ON UNFORMED SURFACES**

Horizontal or nearly horizontal surfaces which are not cast against formwork shall be finished to the class shown on the Drawing and defined hereunder.

**(1) UF 1 Finish**

All surfaces on which no higher class of finish called for on the Drawing or instructed by the Engineer shall be given a UF 1 finish.

The concrete shall be levelled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

## STANDARD SPECIFICATIONS FOR IRRIGATION AND RIVER TRAINING WORKS

### (2) UF 2 Finish

This is a floated finish for roof or floor slabs and other surfaces where a hard trowled surface is not required. The surface shall first be treated as a class UF 1 finish and after the concrete has or machine sufficient only to produce a uniform surface free from screed marks.

### (3) UF 3 Finish

This is a hard trowel led surface for use where weather resistance or appearance is important, or which is subject to high velocity water flow.

The surface shall be floated as for a UF 2 finish but to the tolerance stated below in Sub-clause 906 (5). When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowel led under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

### (4) Finishing of Bridge Decks

A smooth riding surface of uniform texture true to the required grade and cross section, shall be obtained in all bridge roadway decks.

The placing the concrete in bridge roadway decks shall not be permitted until the Engineer is satisfied that appropriate methods, equipment such as concrete finishers and experienced operator, are employed to finish the deck, and all necessary finishing tools and equipment are available on site and in satisfactory conditions for use.

Bridge deck surfaces shall be within the tolerances state below in Sub-clause 906 (5) for UF3 finish and comply with the following additional requirements: -

The finished surface of the concrete shall be tested by means of a straightedge 3 m long and when the surface is not covered by bituminous surfacing or other cover, the surface of the concrete shall not vary by more than 3 mm measured from the lower edge of the straightedge.

### (5) Tolerances

All parts of unformed concrete surfaces shall be in the positions shown on the Drawing within the tolerances set out in Table 9.3.

In case where the Drawing call for tolerances other than those given in Table 9.3 the Drawing shall rule.

**Table 9.3: Tolerances**

Class of finish	Tolerances in mm (See Note)		
	A	B	C
UF1	Not applicable	10	+20 to - 10
UF2	Nil	10	+20 or - 10
UF3	Nil	5	+12.5 or - 7.5

*Note: The tolerances A, B and C given in the table are defined as follows:*

A is the maximum allowable value of any sudden change of level in the surface.

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- B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three-meter-long straight edge or correctly shaped template place on the surface.
- C is the maximum allowable value of the in level or position between a three-meter-long straightedge or correctly shaped template placed on the surface and the specified level or position of that surface.

### 907 REMEDIAL WORK TO DEFECTIVE SURFACES

If no removal of any formwork the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to the Engineer's inspection and the receipt of any instructions which the Engineer may give Defective surfaces shall not be made good by plastering.

Areas of honey combing which the Engineer agrees, shall be repaired after cutting back to sound concrete when the concrete is no more than 3 days old. Care shall be taken that reinforcement and sheathing ducts are not damaged. The cavity shall have sides at right angles to the face of the concrete. After cleaning out with water and compressed air, a thin layer of cement grout shall be brushed on to the concrete surfaces in the cavity. It shall then be filled immediately with the concrete of the same class as the main body. The concrete shall be prepared from the aggregate of maximum size 0.5 times the depth of the cavity or 20 mm whichever is the smaller. A form provided with a lip to enable concrete to be placed shall be used against the cavity. The form shall be filled above the top edge of the cavity.

After seven days the lip of concrete shall be broken off and the surface shall be ground smooth. When the concrete is more than three days old, areas of honey combing shall be repaired using an epoxy bonding agent with a method approved by the Engineer.

Surface irregularities which are outside the limits of tolerance set out in Clause 906 shall be ground down in the manner and to the extent instructed by the Engineer.

Blowholes in vertical surfaces shall be filled with laitance, or mortar using fine aggregate not larger than 0.3 mm, rubbed over the affected area with a rubber face float and finished with polythene.

Defects other than those mentioned above shall be dealt with as instructed by the Engineer.

### 908 MEASUREMENT

Unless stated otherwise, the formwork for concrete in Plain Concrete or Reinforced Concrete or Pre-stressed Concrete shall be measured for payment in square meter of the surface area of concrete which is in contact with formwork in accordance with this Section. Similarly, Falsework shall be measured in square meter for payment.

### 909 PAYMENT

The formwork and false work specifically provided as a separate item, shall be paid as per the contract unit rate. The Contract unit rate shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.

**SECTION 1000: ROOFWORK**

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## SECTION 1000: ROOFWORK

### 1001 SCOPE OF WORK

This Section covers the construction of roof using different materials such as CGI Sheet, GI sheet, Corrugated Fiber Glass sheet, Corrugated asbestos cement sheet, Slate, Thatch Roof, Lime concrete(1:1:3) etc. and other roofing arrangements as required.

### 1002 GENERAL

The Contractor shall be responsible for construction of different roofs shown on the Drawing in accordance with this Section and other relevant Section of these Specification. Before construction begins, the Contractor shall submit to the Engineer Drawing showing details of the proposed roof work as the case may be.

### 1003 MATERIALS

#### (1) CGI ROOFING SHEET

The CGI roofing sheet may be plain or colored as shown in the drawing. The surfaces of the sheets must be clean, bright and free from rust; any sheet showing a white powdery substance shall not be entertained. The material for CGI roof sheets (Iron) shall be galvanized after the process of corrugation. Engineer shall not accept Iron (used for CGI sheet) galvanization before the process of corrugations. The thickness of CGI sheet shall not be less than 0.63mm as specified in IS code 12093 and plain GI ridge of approved brand and color shall be used.

#### (a) Laying and Fixing

CGI Sheets are laid over purlins, one at each end and one in the middle of each sheet. Each sheet is laid with end lap of 150 mm and the side laps should be of 2 corrugations. The sheets are either riveted or jointed with limpet washer. The rivet holes should be drilled & all holes should be in ridges and never in gutters. The tools must be very sharp so that there is no tearing. It is better to rivet 3 or 4 in breadth and then hoisted to the position. The rivet holes should be about 224 mm apart on the sides and at every second corrugation at the ends where four sheets overlap. It is better to drill the holes not punches.

All rivets will be G.I. and will be passed from below with a lead washer on the top extending 12 mm round beyond the edge of the hole. Care should be taken that the sheet is well supported underneath and no inundations are made on the upper surface. The sheets are secured to the iron purlins by means of 10 mm dia. hooks or bolts passing through the sheets and 75 mm screws to the wooden purlins. The bolt holes should be slightly larger than the diameter of the bolts and covered with a limpet or leaden washer. All rivets, bolts etc. should be set in white lead.

#### (b) Ridge and Hips

The ridges and hips are covered by plain G.I. riveted sheets and fastened with limpet washers to Plain GI sheets and overlap of 300 mm on each side and joint

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set in white lead.

The sheets should be fastened at eaves and ends, by continuous length of flat steel bars called "Wind Ties" which are usually 40 mm x 6 mm with slotted holes bolted down to the bressummer or rafter at about 100 mm intervals. These bolts should not be less than 45 mm in length with 150 mm square plates over pillars or walls. The projection at eaves is generally 32 mm to 50 mm.

The pitch is sloped up to 25 to 40 degree. The finished surface shall be uniform and the lines of corrugations shall be uniform and the lines of corrugations shall be straight and parallel.

### (2) Corrugated Fiber Glass Sheet

Corrugated fiberglass sheets, commonly used for roofing, are made from fiberglass reinforced with polyester resin, which makes them resistant to corrosion and various weather conditions. They are used for roofing because of their lightweight, durability, UV Resistance, versatility, cost-effective nature, ease of installation and fire resistance property. It's worth noting that while corrugated fiberglass sheets offer many advantages, they may have some limitations as well. For instance, they may not be as insulating as other roofing materials, such as metal or foam panels. Additionally, proper installation techniques and maintenance are crucial to ensure their long-term performance.

The material shall be composed of a thermosetting styranated or acrylated polyester resin system reinforced with glassfibre. The glassfibre used as reinforcement shall be in the form of chopped strand mat having a highly soluble modified polyester binder in accordance with IS 11551: 1986 having a density of 450 g/m<sup>2</sup> and minimum width of 500 mm.

The sheets shall have a smooth surface finish on both sides. The thickness of the sheet shall be 1.1mm with tolerance of 0.15mm when measured with thickness gauge. The thickness shall be measured at least at 10 random points on all the four Sides and the average value shall be taken (IS 12866:1989).

The glass content in the laminate shall not be less than 30 percent of its original weight. The sheets shall not absorb water in excess of 0.3 percent of its weight. When the sheets are tested for its hardness, the Barcol hardness shall not increase by more than 30 percent of its initial value (IS 12866:1989).

### (3) Slate Roofing

Slates are widely used for roofing work. They are rectangular in shape with uniform thickness. The specific advantage of these roofs is the ease of maintenance, since any broken slate may be easily replaced without much disturbance to the roofing as a whole. Generally slates of sizes, 60 x 30 cm, 50 x 25 cm and 40 x 20 cm and of thickness not less than 15 mm, shall be used for roofing.

The slate for roofing shall be free from veins, cracks, or other similar source of weakness. They shall be of uniform colour and texture and shall not contain white

patches and deleterious minerals. The slate shall be of reasonably straight cleavage and the grains shall be longitudinal. The slates shall be hard and brittle but not tough. When struck, it shall give ringing sound and shall not break when it is let fall flat on hard ground from a height of 1.25 metres. The surface of the slates shall be such as to permit proper laying of the slates. The slates shall be impervious to moisture. The percentage absorption by weight of the slate after it is kept immersed in water for a period of six hours shall not be more than 2 percent of its weight before immersion. When the slate is kept dipped on edge in water for six hours, the water level shall not rise to more than 12 mm and the immerse & edge shall not show signs of swelling, splitting, or flaking.

**(4) Clay Tile Roofing**

The terracing clay tile shall be made from good soil of even texture and shall be uniformly well burnt. They shall be uniform in shape and sizes and shall be free from irregularities, such as twists, bends, cracks and particles of stones. The Clay tiles are found in different dimensions. The tolerances in length, width and thickness shall be of  $\pm 3$  percent. The maximum warpage for the tiles measured shall not exceed 2 percent of the dimensions in any direction. The water absorption by weight when tested according to the method described in IS 3495 (Part 2): 1992 shall not exceed 20 percent. The modulus of rupture in bending when tested as per IS 2690 (Part 2): 1992, shall not be less than 1.5 N/mm<sup>2</sup>.

**(5) Cement Concrete Tile**

Cement Concrete tiles are intended for use as roof covering where durability and appearance are required to provide a weather-resistant surface of specified design. The tiles are manufactured from Portland cement, water, and mineral aggregates and shaped during manufacturing by molding, pressing, or extrusion. Tiles are generally planar or undulating rectangular shapes available in a variety of cross-sectional areas profiles, shapes, sizes, surface textures, and colors. Cement concrete tiles are laid over roofs in 1:4 Cement Sand mortar.

Additionally, proper surface preparation, including cleaning and priming the roof substrate, is essential for ensuring a strong bond between the mortar and the tiles. Adequate curing time for the mortar is also necessary to achieve optimal strength and stability.

**(6) UPVC Sheets for Roofing**

UPVC Sheets are intended for use as roof covering due to its integral properties as heat and sound insulation, fire retardant, chemical resistance, non-corrosive, water proof, high strength, eco-friendly, etc. It is available in various sizes and colors with varying thickness ranging from 1mm to 3mm. UPVC sheets manufactured using materials such as PVC Resin, Stabilizers, Impact Modifiers, UV Stabilizers, Pigments and Colorant, Fillers, etc. are processed and mixed together using extrusion or calendaring techniques to form the UPVC sheets with the desired thickness, surface finish, and other characteristics. The finished products of UPVC sheets shall be examined to verify the composition and

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compliance with applicable regulations to ensure the safety, quality, and environmental sustainability of the product before use.

UPVC sheets shall have a smooth surface finish on both sides. The thickness of the sheet shall be 2 mm or 3 mm as required with tolerance of 0.15mm when measured with thickness gauge. The thickness shall be measured at least at 10 random points on all the four Sides and the average value shall be taken (IS 12866:1989). The sheets shall not absorb water in excess of 0.3 percent of its weight and density of sheet shall not be less than 1.43g/cm<sup>3</sup>.

### (7) Lime Concreting for Terraced Roof

Lime Concreting for terraced roof shall be of 10 cm thick in 1:1:3 (lime Surkhi brick aggregate). Lime, Surkhi, Brick Aggregate and water shall be as per this specification and other relevant specification under this specification.

### (8) Thatched Roof

The thatch roof is generally mounted on mud wall keeping a slope of 30°. The bamboo frame is prepared by approximately 50 mm diameter sticks, placed across each other about 300 mm apart and tied with babiyo ropes or any other thin strong string, or nailed. The Bamboo mat if required, is laid over the bamboo frame. The bundle of rice paddy straw shall be laid and fixed on the frame as close as possible in such a way that a required thickness of 8 cm or 15 cm of the thatch may be obtained. The thatch shall be projected at least 300 to 450 mm outside the mud wall or supporting structure.

### (9) GI Rain Water Gutter

Rain Water gutter shall be made of plain or colored GI sheet having width ranging from 150mm to 450mm as required and shall be fitted to rain water pipe using required accessories. The surfaces of the sheets must be clean, bright and free from rust and sheet showing a white powdery deposit should not be used. The GI Sheet to be used as rain water gutter shall be galvanized after the process of corrugations.

### (10) Wood works for Ceiling, Main Beam, Cross Beam and Truss

Wooden Ceiling, Main Beam, Cross Beam and Wooden Truss shall be made of sal wood and shall be as per this specification and other relevant specification under this specification.

### (11) Eaves-board

The eaves board, also known as the fascia board, is typically installed horizontally along the lower edge of the roof to provide a smooth and finished appearance to the roofline. It also helps protect the underlying roof structure and aids in directing water away from the building. Eaves boards, shall be 25mm thick and made of sal wood and fixed to the roof using quality nails. The material used for eaves board shall be as per this specification and other relevant specification under this specification.

**1004 MEASUREMENT**

Unless stated otherwise, the CGI sheet roofing shall be measured in Sqm. and plain GI sheet ridge in Rm. Corrugated Fiber Glass Sheet shall be measured in Sqm and Fiber Glass ridge in Rm. Slate roofing shall be measured in Sqm. Clay tile roofing shall be measured in Sqm and Clay tile ridge shall be measured in Rm. Cement Concrete Tile shall be measured in Sqm. UPVC Sheet shall be measured in Sqm. Lime Concreting for Terraced Roof, whose thickness is 10cm shall be measured in Sqm. Thatched Roof of required thickness shall be measured in Sqm. GI Rain Water Gutter of specified width shall be measured in Rm. Wooden Ceiling shall be measured in Sqm whereas Main Beam, Cross Beam and Wooden Truss shall be measured in Cum. Eaves-board of required thickness (25mm) shall be measured in Sqm.

**1005 PAYMENT**

The CGI Sheet and GI sheet ridge, Corrugated Fiber Glass Sheet and Fiber Glass ridge, Slate Roofing, Clay Tile roofing and Ridge, Cement Concrete Tile, UPVC Sheets, Lime Concreting for Terraced Roof, Thatched Roof, GI Rain Water Gutter, Wooden Ceiling, Main Beam, Cross Beam, Wooden Truss and Sal Wood Eaves-board shall be paid as per the contract unit rate. The Contract unit rate shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.

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## SECTION 1500 – RIVER TRAINING AND PROTECTION WORKS

### 1501. MANUAL WOVEN GABIONS

#### (1) Scope

This Clause covers the furnishing of materials and construction of gabion works that may be required to act as buttresses, retaining walls, spurs, slope protection and launching, stream or river training structures, check dams, etc to prevent banks or gully erosion.

#### (2) Materials

##### (a) Stone

Stones used for filling the gabion boxes or mattresses shall be clean, hard, sound, unweathered and angular rock fragments or boulders. The specific gravity of the stone shall be not less than 2.50 and the stones shall not absorb water more than 5 percent when tested as per IS: 1124. The length of any stone shall not exceed three times its dimension of the mesh of the crate. However smaller size of stones as spalls shall be allowed for filling voids and its volume including voids shall not be more than 20 percent of the total volume of the stone. Before filling any gabion boxes and mattresses the Contractor shall submit representative samples of the rock he proposes to use in the gabion for approval by the Engineer. Further representative samples shall be submitted for approval each time when there is a change in the type and strength of the rock.

##### (b) Gabion

Gabions shall consist of steel wire mesh crates. The steel wire shall be mild steel wire complying with NS 163-2045. Unless specified otherwise in the contract or on the drawing, all wires used in the manufacturing crates and diaphragms, binding and connecting lids and boxes shall be galvanized with an heavy zinc coating by an electrolytic or hot dip galvanizing process. The weight of deposition of zinc shall be in accordance with NS: 163. Zinc coating shall be uniform and be able to withstand minimum number of dips and adhesion test specified as per NS: 163. Tolerance on diameter of wire shall be  $\pm 2.5$  percent. The tensile strength shall be between 350 to 550 N/mm<sup>2</sup>

In case of rectangular meshed gabion, the wire shall be woven into a rectangular mesh of specified dimensions with two way knots. Gabions with rectangular mesh shall not have diaphragms. In case of Hexagonal mesh, the wire shall be woven into a hexagonal mesh with a minimum of 2 twists as shown in fig 15.1. All edges of the crates shall be finished with a selvedge wire at least 2 gauges heavier than the mesh wire. Gabions with hexagonal mesh shall be manufactured in the standard sizes with specified mesh and wire sizes as shown in Table 15.1.

Diaphragms if required, shall be manufactured of the same materials as the parent gabion box and shall have selvedge wire throughout their perimeter. The number and size of diaphragms to be provided with each crate in case of hexagonal meshed gabion, shall be as given in Table 15.1. All crates shall be supplied with binding and connecting

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wire of the gauges shown in Table 15.1 of sufficient quantity to bind all diaphragms and closing edges.

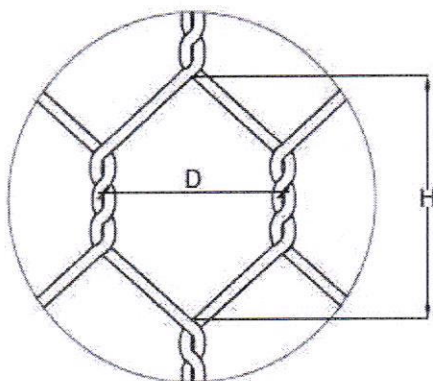


Fig. 15.1 Double twisted wire mesh

Table 15.1: Standard Size of Hexagonal Wire Mesh Gabions

Mesh Type (DXH)	10 X 12	8 X 10	6 X 8
'D', mm	100	80	60
Wire Type	Heavy Zinc coated or other coating as specified		
Mesh Wire Dia., mm / SWG	3.25/10	3.25/10	2.64/12
Edge / Selvedge wire Dia., mm/ SWG	4.06/8	4.06/8	3.25/10
Lacing wire dia, mm/ SWG	2.64/12	2.64/12	2.03/14
Typical Sizes Length x Width x Height (m) / Number of diaphragms	Box Gabions: 3 x 1 x 1 / 2 Nos, 2 x 1 x 1 / 1 No, 1.5 x 1 x 1 / 0 No, 3 x 1 x 0.75 / 2 Nos, 2 x 1 x 0.75 / 1 No, 3 x 1 x 0.5 / 2 2 x 1 x 0.5 / 1 No, 1 x 1 x 0.5 / 0 Nos, 3 x 1 x 0.3 / 2 2 x 1 x 0.3 / 1 No, 1 x 1 x 0.3 / 0 Nos, ,		
Tolerances in Size of Gabion Boxes	Gabion boxes $\pm$ 3%, mesh opening +16 % to - 4 %,		

(c) General Requirements

Before filling any gabion boxes and mattresses, the Contractor shall submit samples of gabion boxes and/or gabion mattresses assembled, erected and filled with stones for approval which, when approved, shall be retained for reference and comparison with the gabions built as part of the permanent works. The size, type and location of the samples shall be as directed by the Engineer.

Gabion boxes and gabion mattresses shall be assembled, erected and filled with stones in the dry on prepared surfaces except as may be otherwise approved. Approval for assembling and erecting gabions in water shall be given only, if in the Engineer's opinion such a method will produce work which is otherwise in accordance with the Specification.

**(d) Preparation of Foundation and Surface for Bedding**

The bed on which the gabion boxes or mattresses are to be laid shall be even and conform to the levels shown on the Drawing. If necessary cavities between rock protrusions shall be filled with material similar to that specified for gabion filling.

**(e) Arrangement of Joints****(i) Walls**

In walls gabion boxes shall be placed such that vertical joints are not continuous, but staggered. Aprons shall be formed of headers. If more than one unit is required to obtain the necessary width, unit of unequal length shall be used and the joints between should be staggered.

**(ii) Channel linings/Slope Protection**

In channel linings, gabion box and mattress units shall be laid so that the movement of stone inside the mesh due to gravity or flow of water is avoided. Hence, on side slopes, unit shall be placed with their internal diaphragms, if provided, at right angles to the direction of the slope and, on inverts, as far as possible, at right angles to the direction of flow.

**(f) Assembly**

Gabion boxes and gabion mattresses shall be assembled on a hard flat surface. After fabrication, unpacking or unfolding, they shall be stretched out and any kinks shall be removed. Creases shall be in the correct position for forming the boxes or mattress compartments. The side and end panels shall be folded into an upright position to form rectangular boxes or compartments. The top corners shall be joined together with the thick selvedge wires sticking out of the corners of each panel. The tops of all sides and partitions shall be leveled except as may be appropriate to special units. The sides and end panels shall be tied together using binding wire of the thickness given in Table 15.1 / 15.4, starting at the top of the panel by looping the wire through the corner and twisting the wire together. Binding shall continue by looping the wire through each mesh and around both selvedges with three rounds which shall be joined tightly together by twisting and the end shall be poked inside the unit. The diaphragms shall be secured in their correct positions by binding in the same way. The bindings wire shall be fixed using 250 mm long nose fencing pliers or equivalent approved tools.

The gabion boxes and gabion mattresses shall be laid in such a manner that the hinges of the lid will be on the lower side on slopes and on the outer side in walls.

Where mattresses are laid horizontally hinges shall not be placed on the downstream side

**(g) Filling**

Except in the case of sack gabions, the crates shall be placed in their final position before filling commences. They shall be stretched to their full dimension and securely pegged to the ground or wired to adjacent gabion before filling. The vertical corners shall be kept square and to full dimension by inserting a steel bay of at least 20 mm diameter at each vertical corner, maintaining it in the correct final position throughout the filling process, and removing it when the crate is full. Before filling commences, the selvedges of the crate shall be bound to the selvedges of adjacent crates with binding wire. Where crates are being assembled in position in a wall the binding of the edges

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of each crate , the assembly process and the binding together of adjacent crates shall be carried out in the same operation.

Before filling with stone, gabion shall be anchored at one end or side and stretched from the opposite end or side by inserting temporary bars and levering them forward. The top and bottom shall be kept stretched by tensioning with tie wires attached to an anchorage or equivalent approved method until the gabion has been filled. The gabions shall be inspected at this stage but before filling with stone to ensure that the tie/wiring has been properly carried out and the gabion boxes or gabion mattresses are not pulling apart. Gabion boxes or gabion mattresses may be tensioned either singly or in the case of a long straight structure by staining a number of units together using an approved tensioning system.

The filling shall be carried out by placing individual stones into the gabion by hand in courses in such a manner that the stones are bedded on each other and bonded as in dry random rubble masonry as per Clause 708. No loose stones shall be tipped into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaied stones shall not be permitted.

All the gabions exposed to outer surface shall be provided with bracing. All 1m deep gabions shall be filled in three equal layers and 0.5 m deep gabions in two equal layers. Horizontal bracing wires made with the same bindings wire as used for tying shall be fixed directly above each layer of the stone in the compartments, the wires being looped round two adjoining meshes in each side of the compartment and joined together to form a double tie which shall be tensioned by wind lacing together to keep the face of the gabions even and free from bulges. Bracing wires shall be spaced horizontally along and across the gabions at distances not greater than 0.5 m. Where the upper faces of gabion boxes are not covered with further gabions vertical bracing wires shall be fitted between the top and bottom mesh using two tie wires per square meter of surface.

The ties shall be fixed to the bottom of the units prior to filling and tied down to the lid on completion. Where a double layer of gabion boxes is used to form an apron both upper and lower layers shall have vertical tie wires.

### (h) Securing Lids

The gabion boxes and mattress compartment shall be over filled by 50 mm above their tops to allow for subsequent settlement. The lids shall then be tied down with binding wire to the tops of all partition panels. The lids shall be stretched to fit the sides exactly by means of suitable tool but due care shall be taken to ensure that the gabions are not so full that the lids are overstretched. The corners shall be temporarily secured first.

### (4) Test and Standard of Acceptance

- (a) The gabion wire shall be tested for mass, uniformity and adhesion of zinc coating and tensile strength of the wire itself. Failure of test results to comply with the specifications shall lead to the rejection of gabion wires. The test on the samples taken as per Table 15.2 from each lot of the G.I. wire received at the side of the work shall be carried out in accordance with NS 163-258.

**Table 15.2: Scale of Sampling and Permissible Number of Defective**

No. of coils in a lot	No. of coils randomly	Permissible no. of
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	selected for sampling*	defective coil
**Upto 25		0
26-50	3	0
51-150	5	0
151-300	8	1
300 and above	13	1

\* One sample per coil shall be tested in all respect

\*\* Up to 25 No of coils the contractor shall submit the manufacture's certificate complying the required specification to the Engineer. The manufacturer should have got the NS mark for the production of GI wire from Nepal Bureau of standard and Methodology,

(b) The stones shall be tested for specific gravity and water absorption. At least 3 set of tests shall be made for every source of material. The test results shall meet the specified criteria.

**(5) Measurement**

Gabion wire mesh for boxes and mattresses shall be measured in sq. meter. The boxes and mattresses shall be physically measured and be verified with their tolerances.

The binding wires, selvedge wire and tension wires shall not be measured separately. They are deemed to be included in the measurement of the gabion boxes and/or mattresses.

Stone filling in gabions including fixing of gabion in position, tying with binding wires and tension wires as specified shall be measured in cu.m.

**(6) Payment**

Gabion boxes, gabion mattresses, stone filling shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications.

**1502. MECHANICALLY WOVEN CRATES (GABIONS AND MATTRESS)**

**(1) Scope**

This specification covers mechanically woven, mechanically selvedged gabions and Reno mattresses produced from double twist wire mesh used for manufacturing, assembling and installation of the product.

This specification covers gabions and Reno mattresses in which the mesh wire, lacing wire and the selvedge wire are (1) Zn coated (2) Zn + PVC (Poly Vinyl Chloride) coated.

Gabions and mattresses shall be manufactured with all components mechanically connected at the production facility. The front, base, back and lid of the gabions shall be woven into a single unit. The diaphragms shall be factory connected to the base. The lid of the Reno mattresses may be a separate piece made of same type of mesh as the basket.

**(2) Terminology**

**Double twisted wire mesh:** a non-raveling mesh made by twisting continuous pairs of wires through three one-half turns (commonly called double-twisted) as shown in fig 15.1, to form hexagonal shaped openings which are then interconnected to adjacent wires to form hexagonal openings.

**Gabion:** Gabions (figure 15.2) are boxes made of hexagonal double twisted woven wire mesh, divided into cells by means of diaphragms which help to reinforce and strengthen the structures. They are interconnected with other similar units and filled with stones at the project site to form flexible, permeable and monolithic structures such as gravity retaining walls, channel linings, weirs etc.

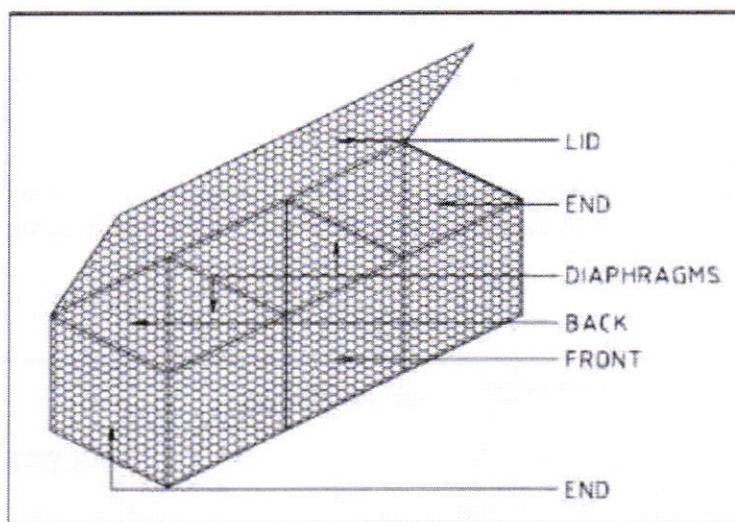


Fig. 15.2 Gabion Box

**Jumbo Gabion:** Jumbo Gabion, if applicable is a special form of gabion with width 1.5 m or 2 m made of hexagonal double twisted woven wire mesh, divided into cells by means of diaphragms which help to reinforce and strengthen the structures. They are interconnected with other similar units and filled with stones at the project site to form flexible, permeable and monolithic structures such as gravity retaining walls, channel linings, weirs etc.

**Reno Mattresses:** Reno mattress (figure 15.3) is a special form of gabion with large plan area / thickness ratio, uniformly partitioned into internal cells by means of diaphragms and having smaller mesh openings than the mesh used for gabions. Reno mattresses are generally used in river training works such as river bank protection, channel lining, launching apron etc.

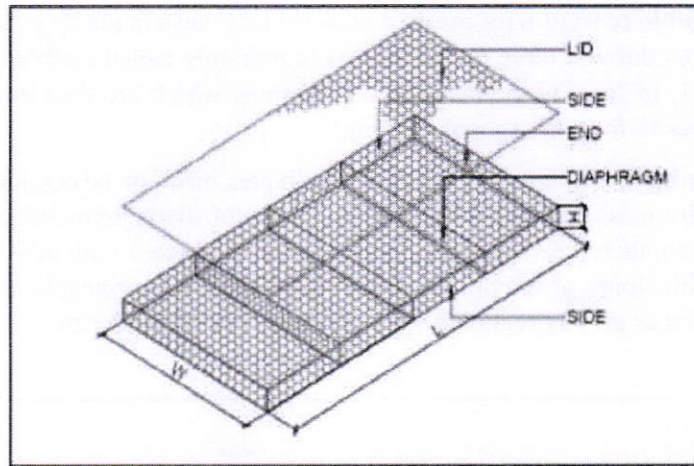


Fig. 15.3 Reno Mattress

**Selvedge Wire:** a terminal wire used to edge the cut portion of wire mesh panel perpendicular to the double twist by mechanically wrapping the mesh wires around it (Fig 15.4).

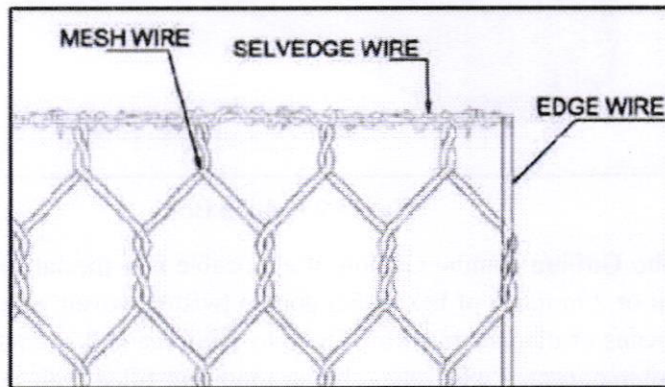


Fig. 15.4 Mechanically Selvedging and Edge Wire

**Main Body:** All edges of the standard gabions should be mechanically selvedged (Figure 15.5) in such a way as to prevent unraveling of the mesh and to develop the full strength of the mesh.

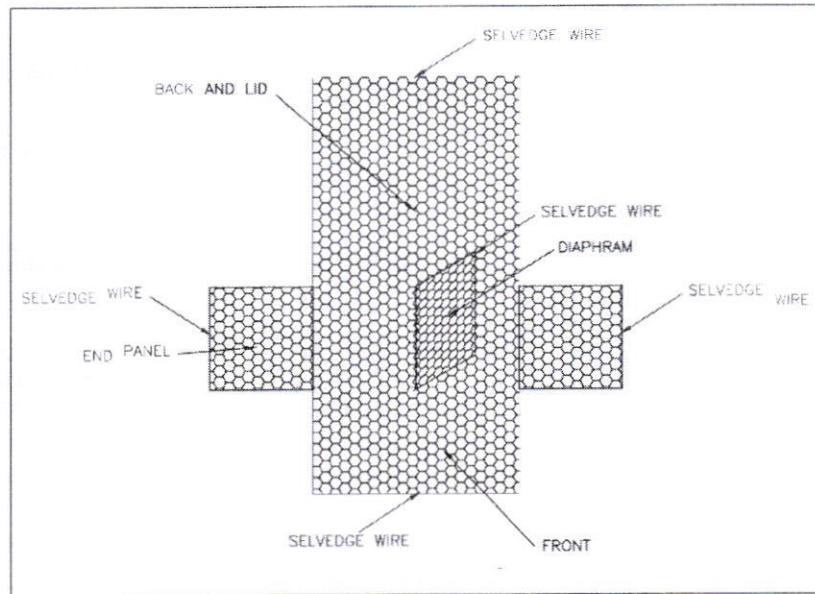


Fig 15.5 Components of Gabions

**End panels and internal diaphragms:** All sides of end panels and internal diaphragms, except the bottom, should be mechanically selvedged (Figure 15. 4) in such a way as to prevent unraveling of the mesh and to develop the full strength of the mesh.

**Edge Wire:** a terminal wire of the same diameter as the selvedge wire used to edge the wire mesh parallel to the double twist by continuously weaving it mechanically into the wire mesh (Fig 15.4).

**Lacing Wire:** a wire with the same coating as per mesh wire used to assemble and interconnect empty units to close and secure stone-filled units and for internal stiffeners.

**Diaphragm:** an internal partition made of same double twisted wire mesh panel in a gabion / Reno mattress that is attached to the bottom, the sides, and, after the gabion cage is packed with stones, to the lid of the cage (Fig 15.2 and 15. 3).

**Connection of end panels to main body:** The end panels in Box gabions should be mechanically connected with the main body at the manufacturing site by Selvedging the both to a common selvedge wire in such a way to prevent the separation of the endpanel from main body even in extreme conditions (Figure 15.2). In Reno mattresses, the end panels are manufactured together with the main body and are folded at manufacturing site to form the end panels

### (3) Mesh and Box Characteristics

Mesh types and shapes shall be as given in Table 15.3. The mesh and Box characteristics of Gabions and Reno Mattresses are given Table 15.4 and 15.5.

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Table 15.3 Mesh types and size

Mesh type	'D' Nominal Size, mm	Tolerances
10 x 12	100	+ 16% to - 4%
8 x 10	80	
6 x 8	60	

Table 15.4 (A) – Mesh & box characteristics for Gabions

Mesh Type	10 x 12				
'D', mm	100				
Wire Type	Zn Coated		Zn + PVC Coated (water side one face thicker)	Zn + PVC Coated	Zn + PVC Coated (water side one face) and other faces Zn coated
Mesh Wire Dia., mm	2.70	3.00	Water Side Face – 3.00/4.00 Other Sides- 2.70/3.70*	2.70/3.70*	Water Side Face – 3.00/4.00 Other Sides- 3.00
Edge / Selvedge wire Dia., mm	3.40	3.90	3.40/4.40*	3.40/4.40*	3.90
Lacing wire dia, mm	2.20	2.40	2.20/3.20	2.20/3.20	2.40
PVC coating thickness, mm	N. A		Nominal – 0.50 Minimum – 0.38	Nominal – 0.50 Minimum – 0.38	Nominal – 0.50 Minimum – 0.38
Typical Sizes	Box Gabions: 4 x 1 x 1 / 3 Nos, 3 x 1 x 1 / 2 Nos, 2 x 1 x 1 / 1 No, 1.5 x 1 x 1 / 0 No, 1.5 x 1 x 0.5 / 0 No, 2 x 1 x 0.5 / 1 No, 3 x 1 x 0.5 / 2 Nos, 4 x 1 x 0.5 / 3 Nos, Jumbo Gabions: NA				
Length x Width x Height (m) / Number of diaphragms					
Tolerances in Size of Gabion Boxes	Length & Width... ± 5%; Height ± 5%				

Table 15.4 (B) – Mesh & box characteristics for Gabions

Mesh Type	8 x 10				
'D', mm	80				
Wire Type	Zn Coated		Zn – Al alloy Coated	Zn + PVC Coated	Zn – Al alloy + PA6 Coated
Mesh Wire Dia., mm	2.70	3.00	NA	2.20/3.20*	NA
Edge / Selvedge wire Dia., mm	3.40	3.90		2.70/3.70*	
Lacing wire dia, mm	2.20	2.40		2.20/3.20	
PVC coating thickness, mm	N. A		N. A	Nominal – 0.50 Minimum – 0.38	NA

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Table 15.4 (B) – Mesh & box characteristics for Gabions				
Mesh Type	8 x 10			
'D', mm	80			
Wire Type	Zn Coated	Zn – Al alloy Coated	Zn + PVC Coated	Zn – Al alloy + PA6 Coated
Typical Sizes Length x Width x Height (m) / Number of diaphragms	Box Gabions: 4 x 1 x 1 / 3 Nos, 3 x 1 x 1 / 2 Nos, 2 x 1 x 1 / 1 No, 1.5 x 1 x 1 / 0 No, 1.5 x 1 x 0.5 / 0 No, 2 x 1 x 0.5 / 1 No, 3 x 1 x 0.5 / 2 Nos, 4 x 1 x 0.5 / 3 Nos,			
Tolerances in Size of Gabion Boxes	Length & Width... ± 5%: Height ± 5%			

Table 15.4 (C) – Mesh & box characteristics for Reno Mattresses				
Mesh Type	6 x 8			
'D', mm	60			
Wire Type	Zn Coated	Zn – Al alloy Coated	Zn + PVC Coated	Zn – Al alloy + PA6 Coated
Mesh Wire Dia., mm	2.70	NA	NA	NA
Edge / Selvedge wire Dia., mm	3.4			
Lacing wire dia, mm	2.20			
PVC coating thickness, mm	N. A	N. A	NA	NA
Typical Sizes Length x Width x Height (m) / Number of diaphragms	6 x 2 x 0.30 / 5 Nos, 5 x 2 x 0.30 / 4 Nos, 4 x 2 x 0.30 / 3 Nos, 3 x 2 x 0.30 / 2 Nos			
Tolerances in Size of Gabion Boxes	Length & Width... ± 5%: Height ± 10%			

- Internal Diameter / External diameter of PVC coated wire
- Only standard sizes of Reno Mattresses are indicated in the table above. Special sizes can also be applied as per instruction of the Engineer.

The Zn coating shall be heavy coating for soft condition conforming to NS 163. For corrosive environment, an additional PVC coating (as per ASTM A 975-2011 of 0.5 mm thick shall be provided over the Zn coating.

**(4) Mechanical Properties**

Where mesh and connection strength is specified, the minimum strength requirements of the mesh when tested in accordance with Clause no. 1502 (6) shall be as shown in Table 15.5

**Table 15.5 –Minimum Strength Requirements of Mesh and Connections**

Mesh Type	10 x 12			8 x 10		6 x 8	
	Zn	Zn	Zn + PVC	Zn	Zn + PVC	Zn	Zn +PVC
Characteristics							
Mesh Wire Dia. (mm)	2.7	3.0	2.7	3.0	2.7	2.2	NA
Parallel to twist (kN/m)	36.0	46.0	36.0	55.	45.	36	
Perpendicular to twist (kN/m)	18	22	18	26	20	18	
Selvedge Strength (kN/m)	18	20	18	20	18	11	
Panel to Panel Connection using lacing wire or fasteners (kN/m)	10	11	10	20	16	11	
Punch Test (kN)	20	22	20	27	22	20	

**(5) Physical Properties****(i) Mass and adhesion of Zinc Coating**

The coating weights shall conform to the requirements of NS: 163/ IS: 4826 Heavily Coated and soft type as shown in Table 15.6. The zinc coating shall remain adherent to the steel wire and conform to such that zinc coating does not flake off, nor crack to such an extent that there is possibility of removing any zinc by rubbing with bare fingers

**Table 15.6 Minimum Mass of Zinc Coating and Permitted tolerances on galvanized steel wire diameters**

Nominal Diameter of Galvanized wire, mm	Mass of Zinc coating, g/m <sup>2</sup>	Permitted tolerances (+/-) on wire diameters ,mm
2.00	240	0.05
2.20	240	0.06
2.40	260	0.06
2.70	260	0.07
3.00	270	0.08
3.40	270	0.09
3.90	280	0.10

**Uniformity:** The coating on the wire shall be reasonably uniform as judged by the copper sulphate solution dip test. Number of dips shall be as per the table below:

**Table 15.7 Uniformity of zinc coating:**

Diameter of wire (mm)		2.00	2.20	2.40	2.70	3.00	3.40	3.90
Uniformity	Nos. of dips (each dip of 1 minute duration)	3	3	3	3	3	3	3
Test	Nos. of dips (each dip of 1/2 minute duration)	-	-	-	1	1	1	1

**Adhesion:** The adhesion of the zinc coating shall be such that, when the wire is wrapped six turns around a mandrel of 4 times the diameter of the wire, it does not flake or crack to such an extent that any flakes of zinc can be removed by rubbing with the bare fingers.

#### **Tensile Strength**

The tensile strength of wire used for double-twisted mesh, lacing wire, and stiffener, when tested shall be in accordance with the requirements of IS 280 for soft wire (350-550 MPa) at a minimum elongation of 10 percent, performed on a gauge length of test specimen as 200 mm.

#### **(ii) PVC (Polyvinyl Chloride) Coating**

The initial properties of PVC coating material shall have a demonstrated ability to conform to the following requirements

#### **Specific Gravity**

In the range from 1.30 to 1.35 when tested in accordance with Test Method IS 13360: Part 3: Sec 1.

#### **Tensile Strength**

Not less than 20.6 MPa when tested in accordance with Test Method IS: 13360: Part 5: Sec 1

#### **Hardness**

Shore "D" between 50 and 60, when tested in accordance with Test Method IS: 13360: Part 5: Sec 11

### **(6) Test and standard of acceptance**

**Tensile Strength of Wire Mesh Panel**— The wire mesh specimens shall be representative of proper field construction as to materials, mesh geometry, and workmanship, and shall be as large as practical to minimize the effect of variations. The tests shall be run with the load applied parallel to the axis of the twist and repeated on a separate test specimen with the load applied perpendicular to the axis of the twist.

The mesh shall be placed into the machine grips such that the gripped mesh will be maintained in the mesh geometry characteristic of field use. The specimen of approximately 0.8m width and 0.5m height shall be tested. The effective width to be considered for test specimen shall be the distance between two extreme gripping points. The specimen should extend by at least one mesh repetition beyond the extreme

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gripping points on either side. However, specimen should not extend more than two mesh repetitions beyond extreme gripping points. The mesh shall be pre-loaded to 10% of the specified minimum strength and machine head travel stopped. The mesh gauge dimensions shall be recorded at this time and taken as the initial dimensions of the specimen where such dimensions are required. If the sample slips at any of the gripping point during the test, such a test shall be discarded and a new sample shall be taken. The loading shall then continue uniformly maintaining the displacement rate of 75 to 100mm per minute until first fracture or unwrapping of an individual wire in the system occurs. The distortion of the mesh or changes in gauge length shall be measured to accuracy consistent with reporting the percent elongation to the nearest 0.5 %.

**Pull-Apart Resistance Test:** Where Pull-aprt resistance test is specified, the test procedure for performing the pull-apart resistance test shall be in accordance with the test procedure as per Clause 13.1.2 of ASTM A975-11.

**Metallic Coating Weight** – Perform coating weight tests and adhesion tests shall be performed in conformity with IS: 4826.

**PVC Coating-** The thickness and other parameter of the PVC coating shall be measured in accordance with IS: 16014.

### (7) Construction

#### i. General Requirements

Clause 1501 (2) (c) shall apply

#### ii. Preparation of Foundation and surface bedding

Clause 1501 (2) (d) shall apply

#### iii. Arrangements of Joints

Clause 1501 (2) (e) shall apply

#### iv. Assembly

Clause 1501 (2) (f) shall apply

#### v. Filling

Clause 1501 (2) (g) shall apply

#### vi. Securing Lids

Clause 1501 (2) (h) shall apply

### (8) Measurement

Mechanically woven Gabion wire mesh and mattresses shall be measured in sq. meter. The boxes and mattresses shall be physically measured and be verified with their tolerances.

Stone filling in gabions including fixing of gabion in position, tying with binding wires and tension wires as specified shall be measured in cu.m.

### (9) Payment

Mechanically woven Gabion wire mesh, gabion mattresses, stone filling shall be paid as per respective contract unit rate which shall be the full and the final compensation

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to the Contractor as per Clause 112 to complete the work in accordance with these Specifications.

### 1503. GEOSYNTHETICS FOR WORKS

#### (1) Scope

The specification covers the various applications of geosynthetics materials for use in river training works including supplying and laying as per contract specifications.

#### (2) Terminology

Geosynthetic is a general classification for all synthetic materials used in geotechnical engineering application. It includes geotextile, geogrids, ego-trips, geomembrane, geonets, geocomposites, geocells etc. Textiles made from natural fibers such as jute, and coir referred to herein under natural Geotextiles may also be used in different geotechnical engineering applications.

- i. **Geotextile:** Any permeable synthetic textile used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

The geotextile fabric shall be a woven or non-woven or knitted fabric consisting of long-chain polymeric filaments or yarns such as polypropylene, polyethylene or polyester or any combination thereof, formed into a stable network such that the filaments or yarns retain their relative position to each other.

There are several application areas for Geotextile requiring specific functions namely separation, filtration, drainage, reinforcement, protection or a combination thereof.

- ii. **Geogrids:** A deformed or non-deformed netlike polymeric material used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of human-made project, structure, or system.

Geogrids have relatively high strength, high modulus, and low-creep-sensitive polymers with apertures varying from 10 to 100 mm in size or more. The openings/holes in geogrids are either elongated ellipse, near squares with rounded corners, squares or rectangles. Geogrids can be of uni-axial grid, bi-axial grid or three dimensional grids. Geostrip is another form of Geogrid, which is used in reinforced soil structures. It is primarily made of synthetic material in strips and is made from high tenacity polyester yarn and contained in a suitable low density polyethylene sheath. These are used as reinforcement in pavements and reinforced soil walls and slopes.

- iii. **Geomembrane:** An essentially impermeable membrane (liner or barrier) used with foundation, soil, rock, earth, or in any other geotechnical application as an integral part of human-made project, structure, or system, used to control fluid migration.

Geomembrane are mostly made from HDPE, LDPE, PVC or polyethylene sheets, which are duly protected from ultraviolet exposure by carbon black or any antioxidants and thermal stabilizers.

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Geo-clay-liners are also, in most cases, consider as geo membrane due to their low permeability performances and can be typically used as an alternative to Polymeric Geo-membrane under specific circumstances. These are used for slope protection and increasing impervious floor length in hydraulic structure due to its impermeable nature. These may be used as capillary cut off in roads in water logged areas too.

- iv. **Geonets:** Geonets are used in combination with other types of geosynthetics. These are usually formed by continuous polymeric ribs or filament at acute angle to one another. When the ribs are opened relatively large size apertures are formed in a net like configuration.

These are typically used in combination with other geosynthetic materials to form a composite material.

- v. **Geocell:** It is a three dimensional structure with interconnected cells. The geocells are made of polyester/polypropylene/high density polyethylene stabilized with carbon black. Geo cells are used for slope protection and retaining/ river training wall. Geocells may be used in for soil containment purpose. Geocells are filled with local soil or with granular material in the specified thickness to hold the material and distribute the load.

- vi. **Geocomposite:** A manufactured material, which could be a combination of any two or more synthetic materials like Geotextile, geogrids, geomats, geonets and geomembrane etc., in laminated or composite form. One of the popular forms of geocomposite is Drainage Composite. Drainage Composites are formed by combining geotextile or geomembrane with a core of geonet, geomat or serrated/corrugated polymeric materials.

### (3) Marking

Geosynthetic rolls shall be marked with the following information:

- (a) Manufacturer's name
- (b) Roll number
- (c) Grade
- (d) Length
- (e) Date of manufacture; and
- (f) Product identification details

### (4) Packing, Storage and Handling

- (a) Each geosynthetic roll shall be wrapped with a material that will protect the geosynthetic from damage due to shipment, water, sunlight and contaminants. The protective wrapping with a tarpaulin or opaque plastic sheet shall be maintained during periods of shipment and storage.

During storage, geosynthetic rolls shall be elevated off the ground and adequately covered to protect from site construction damage, precipitation, prolonged ultra-violet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 71°C, and any other

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environmental condition that may damage the physical properties of the geosynthetic.

- (b) If the outer layer of the geosynthetic is damaged, or exposed to sunlight for a period beyond that is permitted the outermost wrap of the rolls shall be discarded, and only the remaining undamaged/unexposed material shall be used. If the geosynthetic rolls become wet, the water proof cover shall be removed, the rolls shall be elevated off the ground and exposed to wind in order to dry the fabric. The paving fabric used with bitumen overlays shall be completely dry prior to installation.

### (5) Testing and Acceptance

- (a) Geosynthetic Materials Shall is Tested and Certified in the following Manner.
- i. The manufacturer shall have ISO or CE certification for manufacturing process and quality control.
  - ii. The manufacturer shall provide manufacturer's test certificate for every lot supplied from the factory.
  - iii. The supplier shall provide third party test reports from an independent laboratory with valid accreditation for all the test values in Manufacturer's test certificate.
- (b) Geosynthetic shall be tested in accordance with tests prescribed by BIS. In absence of NS codes, tests prescribed either by IS, ASTM, EN, or ISO shall be conducted.
- (c) The material shall meet the requirements as specified in the contract.

## 1504. GEOTEXTILES FOR FILTRATION AND DRAINAGE

### (1) Scope

The work covers the use of geotextile materials for drainage, filtration and erosion control works including supplying and laying as per design, drawing and these specifications. For drainage/filtration function, geotextile shall be able to convey water across the plane of the fabric throughout its design life. For separation function the geotextile shall prevent intermixing of two layers of dissimilar materials, throughout the design life of the structure. The geotextile as a filter material below erosion control measures like stone pitching or stone filled mattresses over the slopes, shall allow the water to flow out and at the same time prevent the loss of soil under the protective measures.

### (2) Material

#### (a) Strength Requirement

The minimum strength of geotextile in terms of MARV under different installation conditions shall be as specified in Table 15.8

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**Table: 15. 8: Minimum Geotextile Strength Property Requirements**

Installation condition	Type	Strength Property Requirement (MARV)							
		Grab Strength in Newton (N) as per IS: 13162 Part 5		Tear Strength in Newton (N) as per IS: 14293		Puncture Strength in Newton(N) as per IS: 13162 Part 4		Burst Strength in Newton (N) as per IS: 1966	
		Elongation at Failure							
		<50%	>50%	<50%	>50%	<50%	>50%	<50%	>50%
Harsh installation condition	Type I	1400	900	500	350	500	350	3500	1700
Moderate Installation condition	Type II	1100	700	400	250	400	250	2700	1300
Less Severe Installation condition	Type III	800	500	300	180	300	180	2100	950

Note:

- (1) All numeric values in the above table represent Minimum Average Roll Value (MARV) in weaker principal direction. The MARV is derived statistically as the average value minus two standard deviations.
- (2) When the Geotextile are joined together by field sewing, the seam strength shall be at least 60 percent of the material's tensile strength. All field seams shall be sewn with thread as strong as the material in the fabric.
- (3) The puncture strength if determined in accordance with ASTM D 6241, the minimum requirement in terms of "Newton (N)" shall be as follows:

The Installation condition	Strength property requirement (MARV)	
	Puncture Strength in Newton (N) as per ASTM D 6241.	
	Elongation at Failure	
	< 50 %	> 50 %
Harsh installation condition	2800	2000
Moderate Installation condition	2250	1400
Less Severe Installation condition	1700	1000

**(b) Ultraviolet Stability Requirements**

The material shall satisfy the ultraviolet stability requirements specified in Table: 15.9.

**Table: 15.9: Requirements for Ultra Violet Stability**

S.No	Properties of Fabric	Requirements(Retained Strength)
1	Grab Strength	Not less than 70% after 500 hours of exposure
2	Tear Strength	
3	Puncture Strength	
4	Burst Strength	

**(c) Hydraulic Requirements for various applications****i. Subsurface Drainage and filtration**

The geotextile shall conform to the physical requirements specified in Table 15.10.

**Table: 15.10: Geotextile Requirements for Subsurface Drainage**

In-situ passing 0.075 mm sieve (%)	Permittivity, per sec, as per ASTM D 4491/ IS 14324 : 1995	Maximum Apparent opening size, mm ASTM D 4751/IS 14294 : 1995
< 15	0.5	0.43
15 to 50	0.2	0.25
> 50	0.1	0.22

The type of geotextile shall be decided by the Engineer depending upon the installation conditions.

**ii. Separation**

The geotextile for different subgrade soil conditions shall conform to the requirements given in Tables 15.11 and 15.12

**Table: 15.11: Geotextile Requirements for Separation (Subgrade Soaked CBR >3)**

S. No.	Geotextile Property	Requirement
1.	Permittivity as per ASTM D 4491	0.02 sec <sup>-1</sup> (per sec)
2.	Maximum Apparent Opening Size as per ASTM D 4751	0.60 mm

**Table: 15.12: Geotextile Requirements for Separation (Subgrade Soaked CBR ≤3)**

S. No.	Geotextile Property	Requirement
1.	Permittivity as per ASTM D 4491	0.05 sec <sup>-1</sup> (per sec)
2.	Maximum Apparent Opening Size as per ASTM D4751	0.43

**iii. Erosion Control**

The geotextile for erosion control shall conform to requirements given in Table 15.13.

**Table: 15.13: Geotextile Requirements for Erosion Control**

In-situ soil passing 0.075 mm sieve (%)	Permittivity, per sec ASTM D4491	Maximum Apparent opening size, mm ASTM D 4751
<15	0.7	0.43
15 to 50	0.2	0.25
>50	0.1	0.22

**(3) Construction****(a) General requirement**

Exposure of Geotextile to the elements between lay down and cover shall be a

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maximum of 14 days to minimize damage potential.

In trenches, after placing the backfill material, the geotextile shall be folded over the top of the filter material to produce a minimum overlap of 300 mm for trenches greater than 300mm wide. In trenches less than 300 mm wide, the overlap shall be equal to the width of the trench. The geotextile shall then be covered with the subsequent course.

Overlap at roll ends and at adjacent sheets shall be a minimum of 450 mm, except when placed under water. In such instances, the overlap shall be a minimum of 1 m. Where seams are required in the longitudinal trench direction, they shall be joined by either sewing or overlapping. All seams and overlaps shall be subject to the approval of the Engineer.

Care shall be taken during installation so as to avoid any damage to the geotextile. Damages, if any, during installation shall be repaired by placing a geotextile patch over the damaged area and extending it 1m beyond the perimeter of the tear or damage, or as approved by the Engineer.

### **(b) Subsurface Drainage:**

Construction shall conform to Clause 1514 of these specifications.

### **(c) Separation**

In the road construction if required, Geotextiles shall be used as separation membrane. After preparation of subgrade as per the specifications along the road alignment, geotextile shall be rolled out as indicated in the drawings. The entire roll shall be placed on the subgrade and unrolled as smoothly as possible. Wrinkles and folds in the fabric shall be removed by stretching as required.

Adjacent rolls of Geotextile shall be overlapped, sewn, or joined as required. For curves, the geotextile shall be folded or cut and overlapped in the direction of construction. Folds in the geotextile shall be stapled or pinned approximately 0.6 m centre-to-centre. Before covering, the condition of the geotextile shall be checked for damage (i.e., holes, nips, tears, etc) by the Engineer.

Before placing the first lift of granular sub-base on the geotextile, a trial stretch of 100 m shall be laid as per roll width to establish a proper construction methodology of placing and compacting the sub-base in a manner that no damages are caused to the separation layer of geotextile.

### **(d) Filter Layer under Stone Pitching for Erosion Control**

The geotextile shall be placed in intimate contact of soil ensuring slight tension, to avoid wrinkles or folds and shall be anchored on a properly shaped surface as indicated in drawings and approved by the Engineer. It shall be ensured that the placement of the overlying material be placed in such a manner that it does not tear/puncture the geotextile. Anchoring of the terminal ends of the geotextile shall be accomplished as per drawings through the use of key trenches or aprons at the crest and toe of slope as required. The geotextile shall be placed with the machine direction parallel to the direction of water flow. Adjacent geotextile sheets shall be joined by either sewing or overlapping. The pitching shall begin at the toe and proceed up the slope. Big sized

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boulders shall not be allowed to roll down the slope.

Any geotextile damaged shall be either replaced or repaired with a patch, as directed by the Engineer, at the cost of the contractor.

### (4) Measurement

The geotextile shall be measured in square metres as per planned dimensions with no allowance for overlapping at transverse and longitudinal joints. Excavation, back fill, bedding and cover material shall be measured separately as per relevant Clauses of the Contract.

### (5) Payment

Geotextile shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1505. GEOGRID

### (1) Scope

The work covers the use of geogrids in erosion control of slopes, reinforced soil slopes and reinforced soil walls including supplying and laying as per design, drawing and these specifications. The use of geogrids as a component for reinforced soil slopes and walls shall be as per contract and instruction of Engineer.

### (2) Materials

#### (a) General

Geogrids shall be either made from high tenacity polyester yarn jointed at cross points by weaving or knitting or thermal bonding process with appropriate coating or from polypropylene or polyethylene or any other suitable polymeric material by an appropriate process. Geogrids manufactured by extrusion process are integrally jointed, mono or bi-directionally oriented or stretched meshes, in square, rectangular, hexagonal or oval mesh form. The geogrids manufactured by weaving/knitting/bonding process shall be formed into a stable network such that ribs, filaments or yarns retain their dimensional stability relative to each other including selvages.

#### (b) Erosion Control

The Geogrid for erosion control application shall have the minimum tensile strength of 4kN/m, when tested as per ASTM D5035 (Minimum Average Roll Value in Machine Direction). The aperture opening size shall be minimum 20mm x 20mm and average grid thickness shall be minimum 1.0 mm. Geogrid for erosion control application shall be UV stabilized. The Geogrid shall have ultraviolet stability of 70 percent after 500hrs exposure as per ASTM D 4355.

#### (c) Reinforced Soil Slopes and Walls

The strength and other requirements shall be as specified in contract.

### (3) Installation and Construction Operations

#### (a) Erosion Control

The Geogrid for erosion control applications shall be installed in accordance with the



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manufacturer's recommendation.

**(b) Reinforced Slopes and Walls**

The Geogrid for reinforced slopes and walls shall be installed in accordance with the manufacturer's recommendation.

**(4) Measurement**

The Geogrid shall be measured in square metres as per planned dimensions with no allowance for overlapping at joints, anchoring at toe and crest of the slope. Excavation, back fill, bedding and cover material shall be measured separately as per relevant Clauses of the Specifications.

**(5) Payment**

Geogrid shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

**1506. GEOCELL FOR SLOPE PROTECTION**

**(1) Scope**

The work covers the use of geocells for erosion control of soil slope including supplying and laying as per design, drawings and these specifications. Geocells filled with local soil or with granular material shall be placed on cut or fill slope to hold top cover soil and allow vegetation to grow.

**(2) Materials**

The geocell is a three dimensional structure consisting of series of cells and resembles a honey combed structure. The geocell shall be made of a suitable polymeric material such as high density polyethylene stabilized with carbon black or nonwoven geotextile.

**(a) Strength and Other Requirements of Geocell**

Geocell shall meet the minimum specifications and properties specified in Table 15.14.

The geocells for erosion control measures shall have cells with nominal opening of 450 cm<sup>2</sup> to 1250 cm<sup>2</sup> and perforations in the cell wall shall be between 11% to 16%. The cell depth for erosion control shall vary from 75 mm to 100 mm. Geocell made from nonwoven geotextile shall meet following specifications.

For anchoring the cells on steep slopes suitable arrangements shall be made as shown on the drawings.

**(3) Installation and Construction Operations**

Prior to laying of geocell on the slope, the surface shall be properly prepared, clean and dressed to the specified lines and levels as shown on the drawings.

<b>Table: 15.14: Requirements of Geocell for Slope Protection</b>			
<b>Property</b>	<b>Test method</b>	<b>Unit</b>	<b>Min. Required Value</b>
Density	ASTM D1505	gm/cm <sup>3</sup>	0.900
Environmental Stress crack resistance (ESCR)	ASTM D1693	Hrs.	3000

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Carbon Black Content		% by Weight	1.5 to 2
Strip / Cell Wall thickness	ASTM D5199	Mm	1.20
Seam Peel-Strength Test		N per 25mm of cell depth.	350
Creep Rupture Strength	ASTM D2990	Creep Rupture Load at 10,000 hours shall be 1 kN minimum obtained from the 95% prediction interval at 10,000 hours considering a logarithmic time/creep rupture model.	

Trench keys along the crest and at the bottom of slope area shall be dug to fix the cellular system in the ground.

Cellular section shall be expanded to the predesigned shape and size, and placed over prepared slope. Geocell sections shall be fastened together using accessories as per manufacturer's installation guide and the drawings.

After cellular sections are secured to the slope, the cells shall be filled with the specified materials ensuring that no damage is caused to the cells. Filling of cells shall be done from the toe of slope to crest of slope.

The fill shall be overfilled between 25mm to 50mm and material shall be suitably tamped to leave soil flush with top edge of cell walls.

Once the soil filling is completed, turfing/ seeding shall be done as recommended.

**(4) Measurement**

The geocell protection work shall be measured as finished work in square meters as per planned dimensions with no allowance for overlapping at joints, anchoring at toe and crest of the slope.

**(5) Payment**

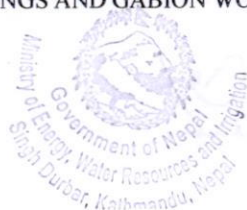
Geocell shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

Unless stated otherwise, the rate specified shall also include turfing, seeding and all other incidental items to cover the work of vegetation on slopes. The quantities of cellular system for erosion control as shown on the drawings may be increased or decreased at the direction of the Engineer based on construction procedure and actual site conditions that occur during construction of the project. Such variations in quantity will not be considered as alterations in the details of construction or a change in the character of the work.

**1507. GEOMEMBRANE**

**(1) Scope**

The work covers the use of geomembrane materials for slope protection and impervious pavement construction works including supplying and laying as per design, drawing and these specifications. Geomembrane shall be able to control water seepage across the plane of the fabric throughout its design life. For impervious pavement construction function the geomembrane shall prevent seepage of water from the pavement



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constructed, throughout the design life of the structure.

**(2) Materials**

Geomembrane are mostly made from HDPE, LDPE, PVC or polyethylene sheets, which are duly protected from ultraviolet exposure by carbon black or any antioxidants and thermal stabilizers. The PVC geo-membrane shall be suitably manufactured from vinyl chloride resin homo polymer. Water soluble compounding ingredient shall not be used. Plasticizers that are resistant to migration and bacterial growth shall be used. The PVC geo-membrane shall be pigmented to produce a uniform colour.

Geo-membrane shall be reasonably free from defects such as holes, tears or blisters. The edges shall be free of nicks and cuts visible to the naked eye. Geo-membrane shall be uniform in colour, texture and finish. The colour, unless specified, shall be black. Geo membranes shall be of various thickness ranging from 0.3mm to 1.5 mm and suitable thickness as specified in the contract or approved by the Engineer shall be selected for the use depending upon the site condition.

**(a) Strength and Other Requirements of PVC Geomembrane**

PVC Geomembrane shall meet the minimum specifications and properties specified in Table- 15.15. The PVC Geomembranes for slope protection measures shall have thickness ranging from 0.3mm to 1.5mm. Suitable thickness shall be used as per contract and/ or approval of the Engineer where decision shall be taken based on the requirement needed for specific site condition. For anchoring the geomembrane on slopes suitable arrangements shall be made as shown on the drawings.

**Table 15.15 Requirements of PVC geomembrane for slope protection**

S.N.	Properties	Requirements	
		Minimum	Maximum
1	Thickness (mm)	0.3	1.5
2	Specific Gravity	1.3	1.4
3	Tensile strength, kg/cm <sup>2</sup>	115	150
4	Elongation at break, percent	250	
5	Tear strength, kg/cm		
	a) Warp	18	40
	b) Weft	20	55
6	Puncture resistance, kg	4	13
7	Hydrostatic resistance, kg/cm <sup>2</sup>	2.5	10

Source: IS 15909: 2010 (Indian Standard PVC Geo-Membranes Specification)

**(3) Installation and Construction Operations**

Prior to laying of geomembrane on the slope, the surface shall be properly prepared,

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clean and dressed to the specified lines and levels as shown on the drawings. Trench keys along the crest and at the bottom of slope area shall be dug to fix the geomembrane in the ground.

Geomembrane shall be expanded to the predesigned shape and size, and placed over prepared slope. Geomembrane sections shall be fastened together using accessories as per manufacturer's installation guide and the drawings.

After Geomembrane sections are secured to the slope, it shall be covered with the specified materials ensuring that no damage is caused to the geomembrane. Placement of cover material shall be based on the types of cover material.

### (a) Placement of Cement-based Covers

Cover materials shall be used as specified in the contract. Cement-based cover materials include prefabricated pavers or slabs, cast-in-place concrete, or compacted soil cement. A needle-punched nonwoven geotextile should be placed on a geomembrane prior to placing cement-based materials to protect the geomembrane and to enhance cover stability during construction.

### (b) Placement of Granular Materials

Granular materials placed on geomembranes should be limited to a maximum particle size of 0.5 inch order to prevent damage or puncturing of the geomembrane.

During construction of the cover, particular care should be taken to prevent damage to the geomembrane. The cover material should never be pushed down the slope because the gravitational stresses may cause the geomembrane to come out of the anchor trench or cause the liner to tear. Equipment placing the cover material should not be driven directly on top of the geomembrane. When large trucks or scrapers are used to deliver cover soils, specific haul routes should be planned with temporarily increased soil cover (i.e., 3 to 6 feet depending on equipment size) to protect the underlying geomembrane.

As placement of a soil cover progresses, care should be taken to prevent wrinkles from developing at the leading edge of the soil. The geomembrane should be in intimate contact with the underlying subgrade and, if not, the wrinkles could fold over and be stressed at the apex, which could produce stress cracks over time, leading to excessive leakage.

### (4) Measurement

The Geomembrane for slope protection work shall be measured as finished work in square meters as per planned dimensions with no allowance for overlapping at joints, anchoring at toe and crest of the slope.

### (5) Payment

Geomembrane shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1508. GEO - COMPOSITE DRAINS

### (1) Scope

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The work covers the use of geocomposite drainage system: (i) Fin drains and (ii) Prefabricated Vertical Drains. The work for fin drains shall be carried out in accordance with the requirements of these specifications and to the lines, grades, dimensions and other particulars shown on the drawings or as directed by the Engineer.

Fin drains with plastic core shall be installed for affecting vertical and/ or horizontal drainage.

Prefabricated vertical drains shall be installed in soft saturated subsoils at designed spacing so as to accelerate the rate of consolidation.

(2) **Materials**

(a) **Fin drains or Geo-Composite or Drainage Composite**

Fin drains shall be made of light weight, three dimensional high compressive strength polyethylene cores; and heat bonded or needle punched polypropylene/polyester geotextile provided on one side or both sides of the core as per the requirements. Geotextile used in drainage composite shall meet the requirements as specified in Table 15.16. The properties of the core material shall meet the requirements as indicated in Table 15.17.

**Table 15.16: Geotextile Requirements for Fin Drains**

In-situ soil passing 0.075 mm sieve (%)	Permittivity, per sec ASTM D 4491/ IS 14324 - 1995	Maximum Apparent Opening Size, mm as per ASTM D 4751/IS 14294 -1995
< 15	0.5	0.43
15 to 50	0.2	0.25
> 50	0.1	0.22

**Table 15.17: Properties for Fin Drain Composite**

Property	Test method	Units	Minimum Average Roll value
Tensile strength	EN ISO 10319	kN/m	16
CBR Puncture Resistance	EN ISO 12236	N	3000
Mass per unit area	EN ISO 9864	g/m <sup>2</sup>	650
Thickness of Composite	EN ISO 9863	mm	4.5
In-plane permeability	Hydraulic Gradient, i=1 at 100 kPa pressure EN ISO 12958	l/m	0.55
			Hydraulic Gradient, i=1 at 200 kPa pressure 0.45



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**(b) Prefabricated Vertical Drains (PVDs)/ Band Drains**

The PVDs/ Band Drains shall meet the requirements as specified in Table 15.18

**Table: 15.18: Properties for Prefabricated Vertical Drains/ Band Drains**

S. No	Property	Test Method	Value	
<b>A</b>	<b>Composite Drain</b>			
1	Width		≥100 mm	
2	Thickness	ASTM D5199	≥ 4 mm	
3	Tensile strength	ASTM D4595	>2.00 kN	
4	Elongation at break		>35 %	
5	Discharge capacity	i = 1.0 at, 300 kPa pressure	ASTM D4716	>1.5 x 10 <sup>-5</sup> m <sup>3</sup> /s
<b>B</b>	<b>Core</b>			
1	Material		Polypropylene/ Polyethylene	
2	Configuration / structure		Corrugated, filament, dimpled, studded etc.	
<b>C</b>	<b>Filter</b>			
1	Material		Polyester/ polypropylene	
2	Structure		Nonwoven	
3	Mass per unit area	ASTM D5261	>120 g/m <sup>2</sup>	
4	Tensile strength	ASTM D4632	>500 N	
5	Elongation at break		>45 %	
6	Trapezoid tear strength	ASTM D4533	>150 N	
7	Permeability	ASTM D4491	>5 x 10 <sup>-6</sup> m/s	
8	Apparent opening size	ASTM D4751		

**(3) Installation**

**(a) Fin Drains or Geo-Composite or Drainage Composite**

The installation of fin drains shall be as per drawings. Where fin drains are assembled on site, the assembly area shall be clean and dry. No geotextile or core material shall be exposed to daylight (or any source of ultraviolet radiation) for a period exceeding 50 hours. Where fin drains are laid in a trench, the bottom of the trench shall be free of irregularities and shall be brought to the required level. Rock and other hard protrusions shall be removed and any excess cut in the trench bottom shall be filled and compacted back to the required grade with suitable excavated or imported material as directed by the Engineer. Fin drains shall be capable of being connected longitudinal or laterally into pipe systems or chambers for inflow and outflow purposes. Joints parallel to the direction of flow and any exposed edge shall be protected from the ingress of soil by a geotextile wrapping with a minimum overlap of 150 mm or other measures as approved by the Engineer. The splicing of lengths of geotextile and minimum overlap shall be as per the drawing or as approved by the Engineer.

**(b) Prefabricated Vertical Drains (PVD)**

The installations for PVD shall be as per relevant Clauses of specification.

**(4) Measurement**

Measurement for Fin drain shall be in running meter of its length used in trenches. Measurement of Fin drain shall be in Sqm when used behind retaining wall, below canal lining, below pavement, chimney drain etc. Measurement for payment for PVDs shall be as per specification Clause for drain.

(5) **Payment**

Fin drain shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 1506 in addition to those specified in Clause 112.

**1509 SOIL NAILING SYSTEM (WITH SEMI-FLEXIBLE 3D GALVANIZED STEEL MAT) FOR SLOPE PROTECTION**

**1. Scope**

The **soil nailing system with semi-flexible 3D galvanized steel mat** is a high-quality construction system consisting of a 3 D zinc coated steel grid mat, steel cables, zinc coated distribution bars, injection bore nails, anchors or T-steel nails of different lengths and the necessary fastening elements such as binding loops and cable clamps. It can be used in four different ways in slopes, embankments, road pavements and river control works.

- a) Slope stabilization and protection works as semi-flexible soil nailing system, with or without vegetation
- b) Slope and riverbank erosion control as revetment with or without vegetation
- c) River bed erosion control, in drainages, check dams and causeways
- d) As reinforcement element in road pavement for earthen, gravel and asphalts surface.

**2. Materials /General requirements**

In order that the structure can fulfill its task, minimum requirements regarding the material and dimensional accuracy must be met upon installing the soil nailing system with *semi flexible 3D-steel Mat*. A careful installation of the system allows repairing of deformed/damaged slope parts, improves and protects the general slope stability and allows enduring and permanent greening of the slope.

The contractor is exclusively responsible for observing the minimum installation requirements. No other parts than the prescribed components for **Soil Nailing System with Semi-Flexible 3D Galvanized Steel Mat** must be used. For detail construction guidelines of manufacturers "**Soil Nailing System with Semi-Flexible 3D Galvanized Steel Mat**" shall be referred. In the event of deviations from instructions, the Contractor shall bear the whole responsibility of the work performed.

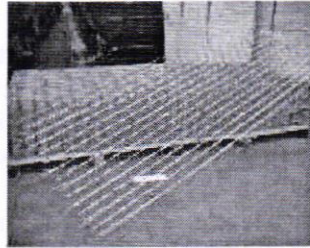
The soil nail system with 3D semi-flexible galvanized steel mat generally comprised of the following materials:

**A) Construction Elements:**

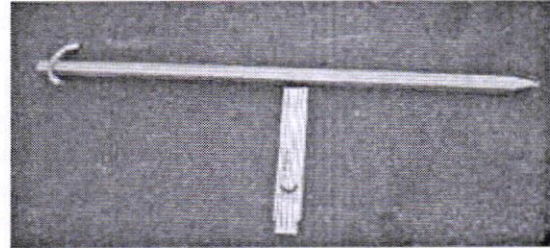
**3 D galvanized steel panels:** The size of the 3D panels varies in length and width: length 2850 – 3200 mm width 1100 – 1200 mm. The height of panel will be 80 mm. A staple of 100 panels (approx. 384 m<sup>2</sup>) will be stapled on one wooden pallet. This profile is made of at least 275 g/m<sup>2</sup> zinc coated steel sheet band of thickness between 1.5 – 1.6 mm.

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- a) **T-section steel nail:** Special designed earth nail made out of steel (T-section profile), size varies from 25/25/3 mm up to 40/40/5 mm with a sharp taper at one end and one hook made out of a round bar  $\phi$ 12 or 16 mm at the other end is used to fix the 3D panels. This nail shall be galvanized to protect it from corrosion. The zinc coating on T-steel nails must be at least 235g/m<sup>2</sup>. The T-steel nails shall have lengths from 0.60m to 3.50 m as required.



3D- Panels

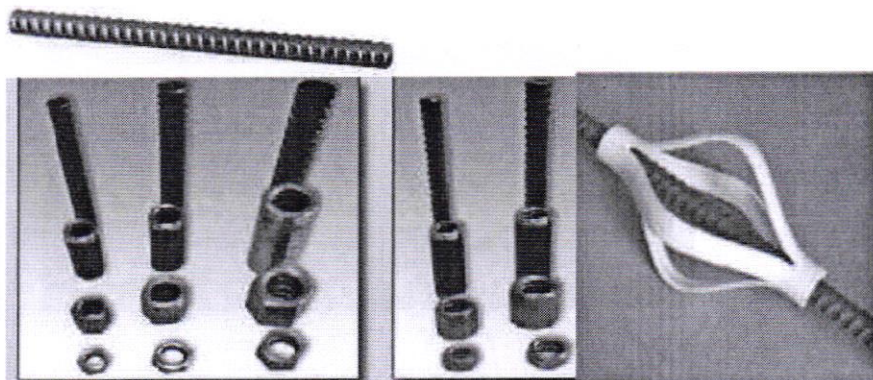


T-Section steel nail

- b) **GEWI nail system:** If the T-section steel nails are not sufficient to provide required level of safety, bored GEWI nails of 28 mm diameter may use to secure the 3D mats.

The GEWI Thread bar System consists of high yield GEWI® screw able steel and corresponding coupling and anchoring accessories, which enable safe and easy connections between anchorages made of GEWI® steel, in accordance with the German approvals Z-1.5-76, Z-1.5-149 and Z-1.5-2.

GEWI Steel High Yield Thread bar is a high tensile alloy steel bar which features a coarse left-hand thread over its full length. The system has proved its efficiency around the world and offers versatility in a range of applications. Manufactured in accordance with the German Certificate of Approval issued by the *Deutsches Institut für Bautechnik*, the system also offers general conformance with BS 4449: 2005 (Carbon Steel Bars for Reinforcing of Concrete). The minimum specified characteristic yield strength is 500 N/mm<sup>2</sup> for bar diameters 16 - 50 mm. These bars can be used in soil nailing at varying lengths between 4m to 8m, but in special situation it can be extended to any design length using special coupling socket connections. 16 - 50 mm bars can also be welded using appropriate industry practices relative to the carbon content of the steel.



GEWI Thread bar (used as nails) and different types of nuts and specially

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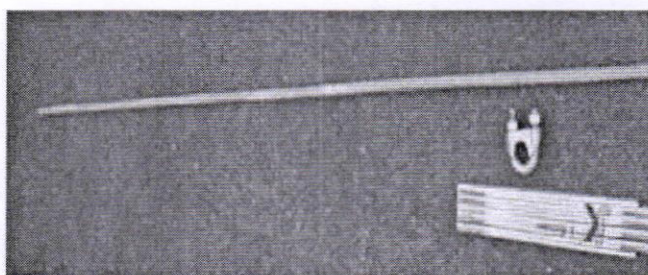
designed PVC spacer for fixing 3D mats

A borehole of 90 mm shall be bored up to the designed length (usually up to 8m) and GEWI bar is inserted and cement grout is filled into this hole and nail is fixed in its position. Centralizers (spacer) made from PVC are available for all hole diameters and nail configurations. Appropriate spacer of other materials can also be used as directed by site engineer.

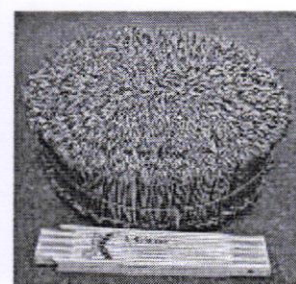
### ***Cement Grout for Filling of the Boreholes in case of GEWI nails***

The source material for the grout are cements with special properties in accordance with DIN 1164-101 and the water in accordance with DIN EN 10085, and (if necessary) additives in accordance with DIN EN 934-26 and aggregates with maximum 4 mm grain diameter in accordance with DIN EN 126209. The water/cement ratio must be between 0.35 and 0.50; in particular in cohesive soils the lowest possible ratio shall be chosen. The cement aggregate mix ratio can be varied from 1:1/2 to 1:1. The cement grout must be mixed mechanically, and must not segregate and lump before it is injected. The minimum compressive strength (28 days) of the grout must be 40 N/mm<sup>2</sup>.

- c) **Distribution rod and rope clip connector:** Distribution bar made of high tensile steel,  $\phi$ 10-12 mm, and length 3700 mm and wire rope clip DIN 741 are used to interconnect the 3D panels and T-Nails. The steel bar is also galvanized to protect it from corrosion. The minimum zinc coating on distribution bars must at least 235g/m<sup>2</sup>. The cable clamps according to DIN 741 and DIN 1142 are used for connecting the distributor rods with each other. Horizontal joints are fastened with two clamps. The connection of a diagonal rod, if any, with a horizontal rod requires only one clamp.
- d) **Connecting elements:** If slope stabilization requires longer, static load-bearing soil nails (bored GEWI nails), soil nails are connected with 12mm dia. steel ropes via especially designed connecting elements and cable clamps. These elements are basically Type 100/166-15/80 ER 16 – 30° and Type 100/232-15/80-DR 16-30° and wire rope clip according to **DIN 1142**.
- e) **Wire rope:** 12mm dia galvanized steel wire rope is used to connect the GEWI nail heads and fasten the 3D mats. The minimum breaking load of such rope must be 90.7 kN. The galvanized wire rope (6x19 SE) must meet the requirements of EN12385-4. The weight per meter of such wire rope will be 0.498 kg.

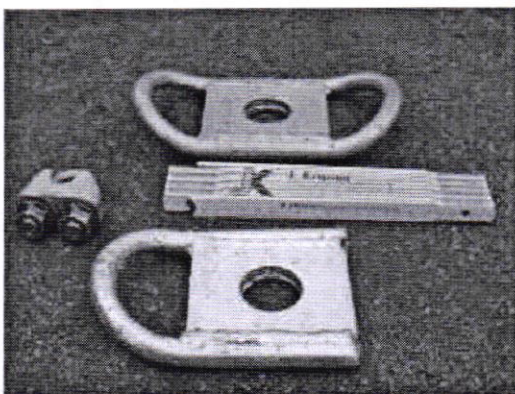


Distribution bar and rope clip connector



Bundle of binding loops





Connecting elements

**B) Backfilling Materials:**

i. **Crushed stone aggregates:** After installation of the 3D panels, they are backfilled with angular material. This permits the creation of a good subsoil structure and hence a gripping layer for the subsequent humus backfill and draining of slope water below the humus layer. Sometimes, use of crushed limestone aggregates has a neutralizing impact on acid soils or in the event of acid precipitation. The crushed stone aggregates of size between 32 mm– 63 mm are preferred for backfill. Moreover, only angular material is appropriate, since round grain can roll out of the panels when filled in. For detail material specification please refer to construction guidelines for soil nailing system with semi-flexible 3D mat. About 3-4 m<sup>3</sup> of crushed aggregates is required for a surface area of 100 m<sup>2</sup>. The filling can be performed with either by machine or manually.

ii. **Humus Material:** Depending upon the site and design of the slopes, humus material is used to make the slope green. Humus (topsoil) is a requirement for any permanent vegetation. Plants protect the slope against erosion. They extract moisture from the topsoil, prevent too fast runoff and the plant roots stabilize the topsoil. Once grown in, the vegetated surface can scarcely be distinguished from the surroundings. A material appropriate for the humus layer or topsoil shall have high humus content (5% at least) and a sufficient content of nutrients (nitrogen, phosphate and potassium). The soil can be blended with compost or manure, if required. In order to ensure long-term adherence of the material to the 3D grid panels, a clay content of 20% - 30% is recommended. For good gripping on steep slopes and increasing its water retention capability, the substrate can be blended with 1% - 2% bentonite. The spraying of humus can be done manually or by using machines. For details please refer to construction guidelines.

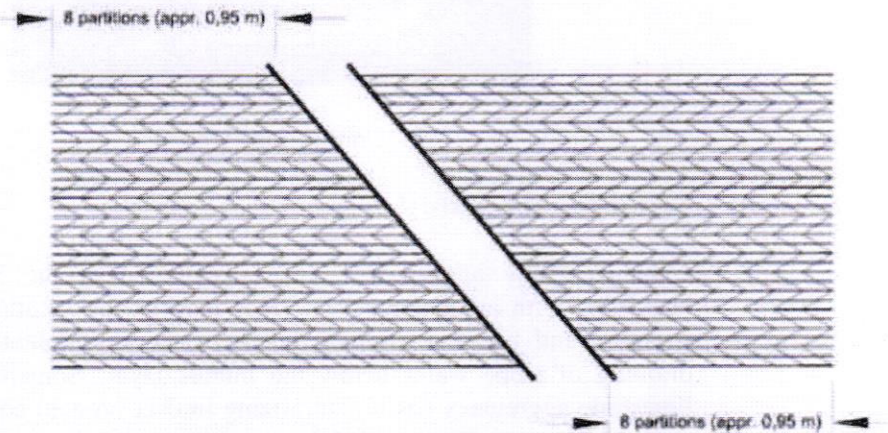
**3. Construction procedure (for slope stabilization and erosion control on slope)**

a) **Preparation of the slope:** The slope shall be trimmed of and leveled. If the level difference between the lowest point of the removed part and the highest point of the existing slope is greater than 40 cm, the depression must be filled with draining capable material before installing the 3D panel. The slope to be stabilized must be cleared from debris until it is free from loose stones. In cases that depressions or trenches are deeper than 40 cm, it is highly recommended to install a separate layer

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of 3D panels before refilling. The edges of the removed part or unstable slope must be rounded off carefully in order to avoid flaws in the slope stabilization upon integration in the native soil.

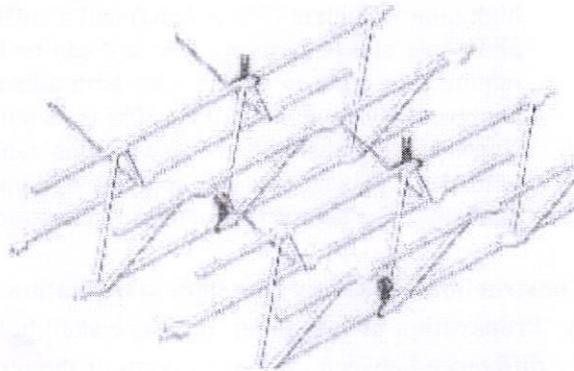
- b) **Cutting the panels:** 3D panels are taken out from pallet and cut diagonally (see sketch below). Diagonal installation of semi-flexible 3d mat in soil nailing system requires that grid panels are cut in two pieces. Make sure that the 3 D panels always are laid on the ground with its arrow-knots-side down. For details see the construction guidelines.



Cutting of 3D panels

- c) **Installation of panels, connections and overlapping:**

After cutting diagonally, the panels are installed from the bottom of the slope at an angle of about 40°-55°. Upon installing the grid panels, make sure that they overlap sufficiently. Overlapping must be 2 knots (approx. 250 mm). Ensure that the panels intermesh well when doing this. The two individual overlapping panels are connected with a wire loop on every 2<sup>nd</sup> cross knot and on every 2<sup>nd</sup> arrow knot. Panels must also overlap crosswise. Overlapping is ½ wave (approx. 40 mm; see drawing). For this, make sure that the panels intermesh well. One wire binding loop is required in every 3 knots while overlapping panels from sides.



Binding with wire loops

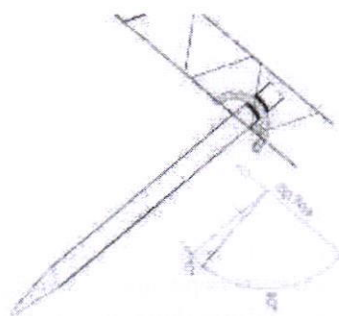
- d) **Insertion of distribution bars:** In order to increase the adherence of the semi-flexible 3d mat into soil nailing system and to the subsoil, round steel distributor

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rods (usual lengths between 2500 – 3700 mm, Ø 10 – 12 mm) are pushed in the grid panel horizontally (and also diagonally if required), during the installation from the side which has not yet been finished. The intervals will be according to the existing nail grid (example: a nail grid of 1.5 m x 1.5 m requires that the rods are introduced in a vertical distance of 1.5 m measured on the slope). If 2500 mm rods are used, rods are pushed in if two widths are installed, if rods are 3700 mm long, they must be pushed in after 3 panel widths. Additional rods can be pushed diagonally in the 3-D steel panels. The spacing must be according to the construction guidelines or system supplier, or as instructed by site Engineer. The distributor rods are linked with each other with 2 cable clamps according to former DIN 714 size 16. For this, make sure that the distributor rods overlap by at least 20 cm – 25 cm. For details refer the construction guidelines. In case of static nails (bored GEWI Nails), steel wire rope is used instead of distribution bars.

- e) **Driving the nails (constructive fastening):** The T section galvanized steel earth nails are driven on the slope in a grid specified (based on the design) according to the local soil characteristics (e.g. consistency, water content, bearing capacity). This is done either manually with a heavy hammer, or mechanically with pneumatic hammer equipped with an appropriate head extension. The individual soil nails should be driven in at a slight angle upwards to the soil surface (approx. 10° to a perpendicular axis laid on the slope) and hence put under tension. As a matter of principle, soil nails must be driven in underneath the distributor rods.

If nails cannot be driven in because of subsoil conditions, in case of solid rock or unconsolidated rock material, holes must be drilled for the nails. To do this, use a manual drilling machine or light weight drilling carriage to drill holes of 28 mm – 32 mm in diameter for nails made out of T 25/25/3.5 mm and 48 – 52 mm in diameter for nails made out of T 35/35/4.5 mm. These holes are grouted with cement mortar (water/mortar ratio  $\leq 0.45$ ) and the soil nail is stuck in the grouted hole. If the subsoil allows it, it is recommended drilling holes approx. 20 cm less deep than the length of the soil nail, and to drive the nail in the remaining length. In this way the nail holds tight immediately in the subsoil and stability and density of the cement mortar are improved. Alternatively, depending upon sub-soil conditions, T-sections nails can also be directly hammered into pre-bored holes of slightly lesser diameter (approx. 5mm less) than the size of T-nails without using any cement grout. In such situation pull out test of T-nails may be necessary to estimate the desired pull out resistance of system nails.



Inclination of T-steel nail

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f) **Soil Nailing System with Semi-Flexible 3D Galvanized Steel Mat in combination with static load bearing soil nails (GEWI-Steel nails):**

If Soil Nailing system with Semi-Flexible 3D Galvanized Steel Mat is used in combination with static load bearing soil nails the 3 D steel panels are connected with round bar anchor bolts or injection grouting nails using special designed connecting elements and wire ropes. After installing (drilling and grouting) the soil nails, first of all, 3D panels are placed on the slope and stuck over the free ends of the soil nails. Then the upper girdles of the 3 D steel panels are cut in a radius of 10 cm around the soil nail head. The connecting element is put on the soil nail head in such a way that it finally lies on the level of the upper girdles of the steel grid.

Following the grid of the soil nails steel cables are installed over the upper girdles of the 3 D panels horizontally (and diagonally if required). The wire ropes are used to distribute the load from the 3 D panels to the soil nails. To get a force locking connection the wire ropes are threaded in the shackle of the connecting element. The cables are clamped with one clamp at every second connecting element.

Then the wire ropes are fixed at one end and pre-stressed by pulling them by hand at the free end. The wire ropes are fastened at both ends making a rope sling with 3 pieces of wire rope clips.

Then the nuts of the soil nails are screwed on and tightened. One may adjust the stress and the ratio of arch of the wire ropes defined in the stability analysis by screwing down the nuts tightly or loosely into the 3 D panels.

g) **Filling with angular material:** After installation of the 3 D panels, they are backfilled with angular material. This permits the creation of a good subsoil structure and hence a gripping layer for the subsequent humus backfill and draining of slope water below the humus layer. The crushed stone aggregates of size between 32 mm – 63 mm are preferred for backfill. Fillings can be done either manually or by using machines. Filling is generally done from bottom to top and it shall be made as compact as possible.

h) **Spray of humus/Top soil:** Depending upon the site and design of the slopes, humus material can be used to make the slope green. The spraying of humus can be done manually or by using machines. A material appropriate for the humus layer or topsoil with high humus content (5% at least) and a sufficient content of nutrients (nitrogen, phosphate and potassium) can be used on the top of gravel layer to ease the growth of plants. The topsoil can be blended with compost, grass seeds or manure, if required. In order to ensure long-term adherence of the material to the 3D grid panels, a clay content of at least 20% -30% is recommended. For good gripping on steep slopes and increasing its water retention capability, the substrate can be blended with 1% - 2 % bentonite. For details about the humus spray machine please refer to construction guidelines.

i) **Draining measures on slopes:** If the slope to be stabilized contains ground water, draining measures must be planned. There are two options for installation of a drainage system using 3D galvanized steel mats:

i) *Drainage without reinforcement.* In flat slopes (up to 45°), drainages can be installed without reinforcement with the 3-D panels. Dig ditches of at least 40 cm depth (maximum depth approx. 80 cm) and fill them with angular material. Arrange ditches in a Y-form down the slope. All earthen sides of the draining ditches must be covered with a non-woven fabric (Geotextile), in order to inhibit fine grains from

  
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penetrating into the drain. The sidewalls of the ditch can be provided with a steep slope of up to 90° according to the stability of the surrounding soil. The draining ditches must be filled before installing the 3D grid on the slope surface to avoid the crumbling of edges and entering the fine grains from the surrounding soil which may clog the draining system.

ii) *Drainage with reinforcement consisting of 3-D panels:* On slopes of an angle greater than 45° there will be a risk of sliding the draining ditch as a whole. This can be avoided by installing the 3D panels on the ditch. For this, the panels are bent up lengthwise according to the ditch dimensions in such a manner that open rectangles form (cross-section formed like a U), and they are then tied up and secured into the ground. Where the depth of ditch is greater than 80 cm and the angle of the slope greater than 55°, the installation of two reinforcing layers (double layer of 3D panels) is recommended. The 3 D panels are fixed in the draining ditch using distributor rods and T – Steel earth nails. To determine the amount of nails to fix the 3D panels inside a draining ditch calculate for a ditch 60cm width approx. 3 pcs of nails per layer for 3 m of drainage length and 4 pcs of nails per layer for a ditch of 1.20 m width per 3 m length. The draining ditch is then filled with the corresponding coarse materials (grain size between 32 and 60 mm). The ditches must be covered with a filter-stable non-woven geo-textile on all earthen sides, in order to avoid penetration of fine-grain earth material. It is recommended to clamp the non-woven geotextile directly on the drainage base and then to put the entire construction of 3D panels into the ditch and fill it up with recommended aggregates. For details of ditch construction on slopes refer to the construction guidelines for soil nailing with semi-flexible 3d mat system.

- 4. Construction procedure (for river bank and river bed erosion stabilization, road pavements)**
- a) The basic installation procedure of the soil nailing system with semi-flexible 3d galvanized steel mat is same as in case of slope stabilization and erosion control on slopes. But in case of river bank and river bed erosion control, it is recommended to use appropriate geotextile on the base of the slope/river bed based on the velocity of flow and river water current.
  - b) It is also recommended to calculate the hydraulic safety (uplift and pull out) of the soil nailing system with semi-flexible 3d galvanized steel mat on the river bank or on river beds (such as launching apron). The nails used to anchor the system must be strong enough to resist the uplift force and pull out from high turbulent velocity during high flood situation.
  - c) Since the angular material inside the 3D panels are mechanically interlocked inside the system, this system (also in multi layers) can be used in river beds for making causeways, temporary diversions and river crossings for all kinds of vehicular traffic loads, which needs special design of this system.
  - d) The soil nailing system with semi-flexible 3d galvanized steel mat can also be used as reinforcing elements in road pavement construction. It can be used in earthen roads, gravel roads and also in asphalt road. All of these special constructions need to be designed separately depending upon the site conditions and Clients requirements. For any special design requirements, it is recommended to consult a design engineer who has an experience of designing the soil nailing with semi flexible 3D mats.

## 5. Quality Control

The soil nailing system with semi-flexible 3d galvanized steel mat elements shall have the following requirements:

### a) 3D Panels

The 3D galvanized steel mats shall be made of high strength steel sheet with at least 275 g/m<sup>2</sup> zinc coating. The thickness shall be 1.5 – 1.6 mm, panel size width 1100 - 1200 mm, Length 2850 - 3200 mm, height 80 mm. The weight shall be approx. 3.0 kg/m<sup>2</sup> to 3.33 kg/m<sup>2</sup> or 10.8 kg/panel to 12.8 kg/panel corresponding to the thickness of sheet steel used (1.5 or 1.6 mm). Approximate loading of Steel type S 350 GD model, for evenly distributed load if knots are fixed shall be 30 kN/m<sup>2</sup>. The Maximum tensile strength of 3D panels lengthwise shall be at least 70 kN/m. The 3D Panels must be supplied by reliable and certified manufacturer.

### b) Other construction elements

The distribution bars, the T-section steel nails, steel ropes, rope clips and binding loops shall meet the entire requirement as mentioned in the specifications and meet all the requirements as mentioned in the construction guidelines “soil nailing with semi-flexible 3d mat system, Instructions for use” or shall be according to the test certificates provided by the recognized manufacturing companies. All of these accessories except 3D panels can be produced locally or procured from local markets but shall be tested for its strength requirements before use.

### c) Design of soil nailing system with semi-flexible 3D galvanized steel mat

Before implementing the soil nailing system semi-flexible 3D mat on a slope, the slope shall be designed to calculate the spacing and length of T-steel nails or special soil nails (GEWI nails). Slopes of similar nature can be constructed on the basis of typical designs prepared for particular road sections with similar soil properties. Based on the available soil data and slope geometry, the typical designs for different heights and slope angles can be prepared in advance.

Reliable finite element programs or appropriate software can be used in the analysis of soil nail system using semi-flexible 3D mat as facing elements. In case of special use of soil nailing system with semi-flexible 3d mat in river bank erosion control, river bed erosion control, causeway design or pavement construction, special designs by a certified geotechnical engineer is recommended.

### d) Construction and workmanship:

The construction of the soil nailing system using semi-flexible 3d mat must be in accordance with its construction guidelines. The spacing and length of installed soil nail should be as designed by the design Engineer. The spacing between two nails shall not exceed by 1.5 m and the minimum length of nail shall be at least 1 m in all situations where the underground material comprises of loose soil or rock material.

## 6. Measurement and Payment

- a) If the typical designs are used with known spacing and length of nails, the measurement of complete construction (whole system) can be done in **square meter** surface area of installed soil nailing system with semi-flexible 3d mat. Depending upon the easiness of construction, it can be divided into two types:

- i. Soil nailing system with semi-flexible 3d galvanized steel mat and T-section

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- nails (1m, 1.5m, 2m, 2.5m, 3m or 3.5m) for slope  $< 45^\circ$  in  $m^2$
- ii. Soil nailing system with semi-flexible 3d galvanized steel mat and T-section nails (1m, 1.5m, 2m, 2.5m, 3m and 3.5m) for slope  $> 45^\circ$  in  $m^2$

Depending upon the use of Humus, it can be with or without humus spray, or humus spray can also be measured separately.

- b) If there is no typical design for the site, the type, spacing and length of the nails are unknown, then the measurement can be spilt into two: **System installation in square meter and nail driving in running meter.**
  - i. Installation of **Soil nailing system with semi-flexible 3d galvanized steel mat** with distribution bar, binding, filling all complete (excluding driving of T- nails) for slope  $< 45^\circ$  in  $m^2$
  - ii. Installation of **Soil nailing system with semi-flexible 3d mat** with distribution bar, binding, filling all complete (excluding driving of T-nails) for slope  $> 45^\circ$  in  $m^2$
  - iii. Driving of T-nails in slope  $< 45^\circ$  in r-m
  - iv. Driving of T-nails in slope  $> 45^\circ$  in r-m
  - v. Driving of bored system (GEWI) nails with grouting in slope

Depending upon the soil/rock type, driving T-nails may need drilling the holes and use of cement mortars, thus different *rates/ rate analysis* shall be applicable.

## 1510. DRY BOULDER LAUNCHING AND SLOPE PROTECTION WORKS

### (I) Big Boulder Pitching for Launching Apron

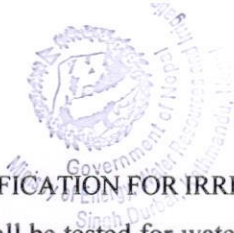
#### (1) Materials

Big Boulder /Stone used for Launching Apron for protection of River banks against scour shall be of required size and weight as specified in the contract or on drawing and shall be from a quarry or arising from the excavation. The weight of the boulder to be used shall not be less than 40 kg or 200 kg as specified. The boulder/ stone shall be sound, hard, and free from cracks or other defects. The boulder/stones, when immersed in water for 24 hours, shall not absorb water by more than 5 percent of their dry weight when tested in accordance with IS: 1124. The specific gravity of boulder/stone shall not be less than 2.65.

#### (2) Construction

The laying of big boulder shall be done as indicated on the drawings. The thickness of launching apron shall be as shown on the Drawing. The boulders not less than 40 kg shall be laid for launching apron manually or using machines depending upon the nature of the river, its flow velocity and the condition of the working site as specified in the contract. The boulders weighing more than 200 kg shall be laid for launching apron using machines for big river with high velocity as specified in the contract. Before laying the boulder, the bed surface shall be made to the required profiles. Depressions shall be made even and thoroughly compacted to the extent possible. Stone/boulder shall be placed to the required length, thickness and depth as per the Drawing. The top surface of the launching apron shall be smooth as far as possible.

#### (3) Tests and Standard of Acceptance



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Stones/boulder shall be tested for water absorption and specific gravity and shall meet the specified criteria. One set of test (3 tests in a set) shall be carried out for every change in source of material and shall meet the specified criteria.

**(II) Boulder Pitching for Slope Protection**

**(1) Materials**

Boulder /Stone used for slope protection of river banks shall be of required size and weight as specified in the contract or on drawing and shall be from a quarry or arising from the excavation. The weight of the boulder to be used shall not be less than 40 kg as specified. The boulder/ stone shall be sound, hard, and free from cracks or other defects. The boulder/stones, when immersed in water for 24 hours, shall not absorb water by more than 5 percent of their dry weight when tested in accordance with IS: 1124. The specific gravity of boulder/stone shall not be less than 2.65.

**(2) Construction**

The laying of boulder over prepared filter media (Geotextile or graded gravel filter) shall be done as indicated on the drawings. The thickness of slope pitching shall be as shown on the Drawing. The boulders weighing not less than 40 kg shall be used for slope pitching manually depending upon the nature of the river, its flow velocity and the condition of the working site as specified in the contract. Before laying the boulder, the slope surface shall be made to the required profiles. Depressions shall be made even and thoroughly compacted. Filter media shall be properly laid on the prepared slope surface before laying boulder/stone. Stone/boulder shall be placed to the required length, thickness and depth over the filter media as per the Drawing. The top surface of the pitching shall be smooth as far as possible.

**(3) Tests and Standard of Acceptance**

Stones/boulder shall be tested for water absorption and specific gravity and shall meet the specified criteria. One set of test (3 tests in a set) shall be carried out for every change in source of material and shall meet the specified criteria.

**(III) Measurement**

Measurement of big boulder shall be in cubic meter. The volume of the boulder shall be measured in the truck / tractor carrying and dumping them near to the working site as directed. The volume for the payment shall be assessed after deducting 15 to 20 % voids (lower value for comparatively smaller size and higher for the bigger size) from the volume measured in the truck.

**(IV) Payment**

Big boulder in launching apron and slope pitching shall be paid for assessed volume (Volume measured in truck less void considered) at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

**1511. CONCRETE BLOCK WORKS IN LAUNCHING APRON AND SLOPE PROTECTION**

**(I) Concrete Block for Launching Apron**

**(1) Materials**

  
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Concrete blocks used for Launching Apron for protection of River banks against scour shall be of required size (0.5m x 0.5m x 0.5m) and weight as specified in the contract or on drawing and shall be made of M15 concrete cast Insitu. The quality of concrete ingredients such as cement, sand, coarse aggregates, water, etc shall be as defined in section 800. The concrete block shall be hard, smooth and free from honeycomb, cracks or other defects. The density of concrete block shall not be less than 2,400 kg/m<sup>3</sup>. The minimum cement content of concrete shall be 250 kg/m<sup>3</sup>.

### (2) Construction

The casting of concrete blocks for launching apron shall be done as indicated on the drawings. The thickness of concrete blocks shall be 50 cm or as shown on the Drawing and approved by the Engineer. The thickness of concrete blocks maybe more than 50cm reinforced with steel as approved by the engineer in case of large rivers having high flow velocity with heavy debris (big boulders, trees, etc.) flow. The casting of concrete blocks shall be done manually or using machine as specified in the contract. Before laying the concrete blocks, the bed surface shall be made to the required profiles. Depressions shall be made even and thoroughly compacted to the extent possible. Hydraulic excavator shall be used for excavation/trimming of river bed for preparation of construction site for casting concrete in case of large rivers. Concrete blocks shall be placed to the required length, thickness and depth as per the Drawing. The top surface of the launching apron shall be smooth as far as possible.

### (3) Tests and Standard of Acceptance

Cement, Sand, Coarse aggregates, water, etc. used for casting concrete blocks shall be tested for their required qualities as per section 800; and quality results shall meet the specified criteria. One set of cube test (3 tests in a set) shall be carried out for every change in source of material and shall meet the specified criteria.

## (II) Concrete block pitching for Slope Protection

### (1) Materials

Concrete blocks used for slope pitching of River banks against erosion shall be of required size (0.3m x 0.3m x 0.3m) and weight as specified in the contract or on drawing and shall be made of M15 concrete cast Insitu. The quality of concrete ingredients such as cement, sand, coarse aggregates, water, etc shall be as defined in section 800. The concrete block shall be hard, smooth and free from honeycomb, cracks or other defects. The density of concrete block shall not be less than 2,400 kg/m<sup>3</sup>.

### (2) Construction

The casting of concrete blocks for slope pitching shall be done as indicated on the drawings. The thickness of concrete blocks shall be 30 cm as shown on the Drawing and approved by the Engineer. The casting of concrete blocks shall be done manually as specified in the contract. Before laying the concrete blocks, the surface shall be made level and smooth to the required profiles. Depressions shall be made even and thoroughly compacted. Concrete blocks shall be placed to the required length, thickness and depth as per the Drawing. The top surface of pitching shall be smooth as far as possible.

### (3) Tests and Standard of Acceptance

Cement, Sand, Coarse aggregates, water, etc. used for casting concrete blocks shall be tested for their required qualities as per section 800; and quality results shall meet the

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specified criteria. One set of cube test (3 tests in a set) shall be carried out for every change in source of material and shall meet the specified criteria.

### (III) Measurement

Measurement for cement concrete blocks in launching apron and slope pitching shall be in cubic meter as specified in the contract.

### (IV) Payment

Cement concrete blocks in launching apron and slope pitching shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1512. DOLOS / TETRAHEDAL FOR RIVER BANK PROTECTION

### (1) Material

Dolos/Tetrahedral may be used for river bank protection against scour and erosion in large rivers like Koshi, Narayani, Karnali, Mahakali, etc. having high velocity and wave action causing danger to river banks. The materials used for construction of dolos/tetrahedral shall be precast concrete of grade M20 or more as specified in the contract or on the drawing and approved by the engineer. The materials (Cement, sand, Coarse Aggregates, Admixtures, Water, Steel, etc.) used for construction of dolos/tetrahedral made of concrete reinforced with steel shall be of required quality conforming to the requirement specified in section 800. Steel form work to be used for casting dolos/tetrahedral shall be of special quality and type depending upon the designed shape of the structure as approved by the Engineer. Unless specified otherwise, the weight of each dolos shall not be less than 6.5 tonne. The weight of each tetrahedral shall be between 0.46 tonne to 5.7 tonne, unless otherwise specified in the contract or drawing. Depending upon the degree of severity of the working site, the size and weight of dolos / tetrahedral maybe varied as approved by the Engineer.

### (2) Construction

The dolos/tetrahedral precasted for use shall be transported to the working site by using heavy equipment as required. The dolos/tetrahedral shall be gradually laid on the required river bank site using heavy crane. Due care shall be taken while placing by crane to ensure maximum interlocking among the members. Laying shall be done for a small length first and shall be tested to conform proper interlocking. If the required interlocking will be achieved, further laying shall be continued upto full length desired. Since the dolos/tetrahedral are heavy elements and their laying by the machine shall be done under water, Evercare shall be taken to ensure the safety working environment.

### (3) Tests and Standard of Acceptance

Cement, Sand, Coarse aggregates, Admixtures, Steel Reinforcement, Water, etc. used for precasting dolos/tetrahedral shall be tested for their required qualities as per section 800; and quality results shall meet the specified criteria. One set of cube test (5 tests in a set- after 3 days, 7days, 14 days, 21 days and 28 days) shall be carried out for every change in source of material and shall meet the specified criteria (compressive strength).

### (4) Measurement

Measurement for precast dolos/tetrahedral used for river bank protection shall be in

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cubic meter as specified in the contract. Unless otherwise specified, Special formwork and steel reinforcement be measured separately.

### (5) Payment

Precast dolos/tetrahedral used for river bank protection shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112. Unless otherwise specified, Special formwork and steel reinforcement shall be paid at respective contract unit rate separately.

## 1513. RCC PILE FOR RIVER BANK PROTECTION WORKS

### CAST-IN-SITU PILES

Cast in situ concrete piles may be either installed by marking a bore into the ground by removal of material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as bored and cast-in-situ piles and driven shell and cast-in-situ piles respectively.

### (1) BORED AND CAST IN-SITU PILES

#### (a) Steel Casing

When permanent steel casing is shown on the Drawing, the minimum thickness shall be 10 mm. The minimum length shall be from 100 mm above the bottom of the pile cap to 5 meter under the river bed or into the firm strata with joints between casings as approved by the Engineer.

#### (b) Concrete

The concrete shall conform to the requirements specified in Section 800. The density and consistency of the concrete shall conform to the termite casting method. Sufficient workability (slump) of all the concrete during the casting and handling of casing including reasonably calculated delays, shall be secured. All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured during concrete tests performed.

#### (c) Reinforcement

The reinforcement shall conform to Section 800.

#### (d) Drilling Fluid

The following requirements shall be complied with, if bentonite mud is used to stabilize the boreholes:

#### (i) Supply

A certificate shall be obtained by the Contractor showing the properties of the consignment delivered to the site. This certificate shall be made available to the Engineer for his approval. The Contractor shall get approval of the Engineer for any other material proposed by him for the drilling fluid.

#### (ii) Mixing

Bentonite and any other material shall be mixed thoroughly with clean water to make a suspension which shall maintain the stability of the pile excavation for the period

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necessary to place concrete and complete the construction.

### (iii) Tests

The frequency of testing drilling fluid along with method and procedure of sampling shall be proposed by the Contractor for approved by the Engineer prior to the commencement of the work. The frequency may subsequently be varied as required, depending on the consistency of the result obtained. The Contractor shall supply all equipment and experienced operators required to carry out tests on the drilling mud. No additional payment shall be made for these tests which shall be considered as an essential part of the drilling operations.

### (e) Construction Methods

The Contractors shall demonstrate to the satisfaction of the Engineer that his proposed construction method for the pile do not weaken the pile shaft by contamination of the concrete by sectional reduction, by washing out of cement, by breaking during pulling of temporary casing or in any other way including the construction of neighboring piles. The Contractor shall describe the construction method he proposes, including information on boring equipment, materials, method of boring and quality control.

The construction procedure shall be as follows:

- (i) If permanent steel casings is not specified, a sufficient length of temporary steel casing shall be used to stabilize the upper part of the borehole.
- (ii) Boring and excavation inside the steel casing shall be carried down to the casing toe level or to a level approved by the Engineer. The excavation shall be continue to final pile tip level using either temporary casing under water or using drilling mud. The fluid level inside casing shall at all times be at least 2 meters higher than outside the casings.
- (iii) All mud or sedimentation from the bottom of borehole shall be cleaned up.
- (iv) Reinforcement cage, inspection pipes etc. shall be placed shown on the drawing or instructed by the Engineer.
- (v) Concreting underwater or drilling fluid shall be carried out continuously using termite method.
- (vi) Withdrawing of the temporary boring casing to the instructed level shall be carried out concurrently with concreting.
- (vii) After hardening, the top section of the concrete pile shall be broken to reach sound concrete in the pile, if pile cap is required for river bank/toe protection.

The Centre of the complete pile at cut off level shall not deviate more than 100 mm from the theoretically correct position shown on the drawing. The inclination of the pile shall not deviate more than 1:100 from vertical. The Contractor shall provide suitable equipment such as inverted pendulum, to check the vertically of the boreholes at intervals during drilling and prior to concreting.

### (f) Boring

Methods of excavation shall be proposed by the Contractor for approval of the Engineer. Piles shall not be bored so close to other piles which are cast and contain workable or unset concrete likely to flow. Boring and excavation for a pile shall not commence until 24 hours after completion of any pile within a radius of 6 meters centre

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to centre. Temporary casing of approved quality or an approved alternative method shall be used to maintain stability of pile excavation which might otherwise collapse.

Pile through water and/or soft upper soil layers shall be provided with permanent steel casing if shown in the Drawing. The pile boring shall be carried out using temporary steel casing bored in pile toe, to the level of side fall or to a level approved by the Engineer. Before concreting the temporary casing shall be gradually withdrawn. Under certain circumstances the Contractor may be permitted to bore all part or the pile without casing under water or using drilling fluid to stabilize the borehole.

Where borehole is formed without casing under water or using drilling fluid for maintaining the stability of a boring, the level of the water or fluid in the excavation shall be maintained so that the water or fluid pressure always exceeds the pressure exerted by the soils and external ground water. The water or fluid level shall be maintained at a level not less than 2 meters above the level of the river water level or any artesian pressure level.

In the event of a rapid loss of water or bentonite suspension from the pile excavation, the excavation shall be backfilled without delay and the instruction of the Engineer shall be obtained before excavation at that location is resumed

### (g) Pumping

Pumping from the borehole shall not be permitted unless a casing has been placed into a stable stratum which prevents the flow of water from other strata in significant quantities into the boring, or unless it can be shown that pumping shall not have a detrimental effect on the surrounding soil or property.

### (h) Removal of Obstruction

Where boulder or other obstruction render it impossible to bore the pile, excavation operation inside pile casing as directed by Engineer shall be carried out to remove obstructions. The Contractor shall be reimbursed from such operation only when the largest dimension of the obstruction exceeds 200 mm and the obstruction is found more than 2 meters below river bed.

Disturbed and/or undisturbed samples of the soils from boreholes shall be submitted to the Engineer. The contractor shall allow for carrying out sampling and tests to check soil strength including field tests like SPT tests as required by the Engineer.

### (i) Final Toe Level of Piles

The final toe level shall be as indicated on the drawing or as instructed by Engineer after due consideration of the Contractor's proposals, boring logs and test results.

The final toe level of other piles may subsequently be altered according to the results of the tests loading detail in the section.

### (j) Inspection and cleaning bottom of Excavation

The time between final excavation including bottom cleaning and the start of concreting shall be reduced as much as possible and in any case shall not exceed 6 hours.

The cleaning shall be done by an approved method. Before cleaning bottom of every excavation, notice shall be given to the Engineer. The Contractor shall show, to the satisfaction of the Engineer, that the bottom of the excavation is clean.

If boring without casing, the diameter of the borehole for a representative number of

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piles shall be measured by calliper to the placing of concrete.

These measurements shall be done by the Contractor using approved equipment and no reimbursement shall be made for this.

**(k) Placing Reinforcement**

The reinforcement shall be placed as indicated on the Drawing. Reinforcement in the form of a cage shall be assembled with additional support, such as spreaders forks and lacings necessary to form a rigid cage. Hoops, links or helical reinforcement shall fit closely around the main longitudinal bars and be bound to them by approved wire, the ends of which shall be turned into the interior of the pile or pour. Reinforcement shall be placed and maintained in position. The cover to all reinforcement shall be not less than 75 mm.

Joints in longitudinal bars in piles with tension (for instance for test loading) shall be carried out by welding unless another method has been approved by the Engineer.

**(l) Placing Concrete**

**(i) Approval from the Engineer**

No concreting shall take place before the bottom of excavation has been cleaned. The Contractor shall get borehole inspected and obtain approval in writing from the Engineer.

**(ii) General Requirements**

While placing concrete, these requirements shall be complied with

- i. The method of placing and workability of the concrete shall be such that a continuous monolithic concrete shaft of the full cross section is formed.
- ii. The concrete shall be placed continuously and without such interruption as would allow the previously placed batch to have hardened. In this respect the Contractor shall submit details of his contingency plans, standby plants etc. to be utilized in the event of an equipment failure.
- iii. The use of pumped concrete and the methods in its use shall be approved.
- iv. The Contractor shall take precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No spoil, liquid or other foreign matter shall be allowed to contaminate the concrete.
- v. Concrete to be placed under water or chilly fluid shall be placed by termite and shall not be discharged freely into the water or drilling fluid.
- vi. Before concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring. The Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the termite, has not accumulated in the bottom of the hole.
- vii. A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, the placing of concrete shall not proceed. In this event the Contractor shall modify the mud quality. The concrete shall be a rich and coherent mix of high workability in accordance with the requirement of Section 800.

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- viii. The concrete shall be placed in such a manner that segregation does not occur.
- ix. During and after concreting damage to the concrete from pumping and dewatering operations shall be avoided.
- x. The hopper and pipe of the termite shall be clean and watering throughout. The pipe shall extend to the base of the boring. A sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the pipe of the termite and the water of drilling fluid. At all times the pipe shall penetrate the concrete placed and shall not be withdrawn from the concrete until completion of concreting. The bottom of the termite pipe shall be kept at least 1.5 meters under the surface of concrete. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or drilling fluid. The internal diameter of the pipe termite shall not be less than 150 mm for concrete made with 20 mm aggregate and not less than 200 mm for concrete made with 40 mm aggregate. It shall be so designed that external projection are minimized, allowing the termite to pass through reinforcing cages without causing damage. The internal face to the pipe of the termite shall be free from projections.
- xi. The Contractor shall maintain a continuous record of the volume of concrete used and the level of the concrete in the pipe. Any deviations from the theoretical, or expected, volume/level relationship shall be immediately reported to the Engineer.

(iii) **Workability of Concrete**

Slump measured at the time of discharge into the pile shall be in accordance with that given in the Table 15.19.

**Table 15.19: Slump of Concrete for Pile Boring**

Pilling mix Workability	Slump		Typical conditions of use
	Minimum mm	Range mm	
A	75	75-150	Placed into water free unlined or permanently lined bore of 600 mm diameter or over where casting level lies below temporary casing; reinforcement widely spaced bearing ample room for free movement of concrete between bars
B	100	100-200	Where reinforcement is not spaced widely where cut off level of concrete is within temporary casing where pile bore is water free and the diameter is less than 600 mm.
C	150	150	Where concrete is to be placed by termite under water or chilly Mud or by pumping.

(m) **Extraction of Temporary Casing**

(i) **Workability of Concrete**

Temporary casing shall be extracted while the concrete within remains sufficient

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workable to ensure that the concrete is no lifted.

### (ii) Concrete Level

When the casing is being extracted a sufficient quantity of concrete shall be maintained in it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated. The toe of the temporary casing shall be kept at a minimum of 2 meters under the outlet of the termite.

Adequate precautions shall be taken in all cases where excess head of water or drilling fluid exists.

The pile shall be concreted with certain over height to allow for chiseling off the top concrete down to sound hard concrete.

### (iii) Vibrating Extractors

The use of vibrating casing extractors shall be permitted for the extraction of the casing.

### (iv) Reinforcement Cage

During concreting and pulling casing, the reinforcement cage shall be secured against uplift the top shall be kept under close monitoring.

### (v) Supervision

The execution of the pile concreting shall be supervised by a qualified and experienced person of the Contractor, who shall keep records on the relation between quantity of concrete used, level of concrete and withdrawal of casing.

## (2) PRECAST RCC PILE

Specification for pre-cast concrete piles shall conform to those contained in Clause 8 of IS: 2911 (part 1 Section 3), if not covered by Section 800. Every pile shall be marked with the date of casting and an identification number. Pre-cast concrete piles to be used for river bank protection shall be of the size (normally 300mm or 500mm dia) and shape (normally circular) as shown on the designed drawing. The length of pile shall be as per the design performed based on site requirement and not normally it should not exceed 25 meters. Piles shall be cast with a driving point for hard driving and shall be cast with a metal shoe approved by the Engineer.

### (a) DRIVING EQUIPMENT

#### i. Pile Driving Frames on leads

Leads shall be required for all types of hammers. Leads shall be so constructed as to allow free movement of the hammer and shall be rigid enough to hold the pile in correct alignment during the driving operation. The leads should be of such length, where practicable, that the use of followers shall not be necessary. The use of hanging leads, guyed leads or other leads shall be subject to the approval of the Engineer, whose approval, if given, shall not relieve the Contractor of the responsibility of driving the piles to the place and vertically tolerances allowed in the contract.

#### ii. Piling Hammers

Pile Hammers, other than drop hammers shall be of approved steam, air or diesel

Hammers that develop sufficient energy per blow to drive the piles at a penetration rate of not less than 5 mm per blow at the required bearing value. Steam or air hammers shall be with boiler or air capacity at least equal to that specified by the manufacturers

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of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gauge. The value, mechanism and other parts of the hammers shall be maintained in good condition and working order so that the length of stroke and number of blows per minute for which the hammer is designed shall be obtained. Inefficient steam, air, or diesel hammers shall not be used and hence such hammers shall be removed from the site. As a general guide the size of the hammer normally required for steel piles shall be one which develops approximately 1100 kg meter energy per blow. Pre-cast concrete piles and steel shell for cast-in-situ piles longer than 15 meters shall normally require a hammer which develops 1725 kg meters energy per blow. Drop hammers shall in no case weigh less than the combined weight of the pile, dolly and helmet. The Contractor shall, furnish the Engineer with evidence of the weight of the drop hammer as he requires.

### iii. Pile Driving Helmets and Dolly's

A driving helmet shall be used which fits closely over the head of the pile. A cushion block of coir or wood shall be used between the pile head and the helmet and the helmet shall have a dolly of suitable material on the upper side.

### (b) PILE DRIVING

#### i. General

The Contractor shall notify the Engineer at least 24 hours before beginning any pile driving operations and no piles shall be driven unless the Engineer or Engineer's representative or his Inspector is present. Before any foundation piles are driven in any unit including test piles, the excavation shall be made, approximately, to the planned footing level. Piles to be driven through embankments over 1.5 m in depth constructed by the Contractor shall be driven in holes excavated through the embankment of dimensions not less than the pile dimensions plus 15 mm. After driving, the space around the pile shall be filled with dry sand or single size gravel. During pile driving operations the water level in the excavation shall be kept below the top of the pile. Under water pile driving shall only be permitted when the contract calls for a concrete seal foundation. In such cases, the piles shall be driven by a mechanical hammer equipped to drive when submerged. When the top of the hammer is submerged during driving, it shall be equipped with accurate measuring detachable measuring rods, for the purpose of recording pile penetration. Care shall be taken to obtain accurate location and spacing of the piling. In all cases of underwater driving, the equipment and method to be used shall be approved by the Engineer in writing. When satisfactory penetration of piles cannot be obtained without damage to the pile from driving, and the character of the soil is considered suitable, the Contractor may with the Engineer's approval use water jets in sufficient numbers to obtain the desired penetration. Before the desired penetration is reached the jets shall be withdrawn and the pile shall be allowed the jetting or the provision of jetting equipment. Water jets shall not be used as an aid for driving steel piling. The driving of piles by means of followers shall be avoided if practicable and shall only be done with the written permission of the Engineer, who may require that one pile from any group of 10 or less shall be a long pile driven without a follower to determine the average bearing power of the group. Sawing or cutting the body of a pile to assist in springing it to proper location shall not be permitted. If a pile vibrates excessively or shows signs of buckling during it shall be braced or guyed as directed by the Engineer. Broken, spilt or wrongly treated piles shall not be measured for payment and if required by the Engineer they shall be completely withdrawn and replaced by satisfactory piles.

**ii. Installation**

Installation of piles shall be carried out in accordance with the pile layout Drawing or as directed by the Engineer.

The Engineer shall decide the sequence of the group of piles that the Contractor should undertake for installation and shall follow this sequence. In a group the installation shall proceed from those on the centre of the group towards those on the periphery.

**iii. Temporary Arrangement**

The Contractor shall ensure that free standing piles are temporarily braced on stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that no damage resulting from oscillation, vibration or movement of any free-standing pile length can occur.

**iv. Tolerance in Driving**

During driving, the piles shall not deviate from the vertical or the specified rake (in the case of raker piles) by more than 40 mm per meter of pile length, and after driving the centre of the pile at cut-off level, shall be not more than 150 mm from its planned location.

**v. Cutting of Pre-Cast Concrete Piles**

Concrete piles shall be cut off at such level that they shall extend into the cap or footing if required for river bank protection as indicated in the Drawing.

**(3) MEASUREMENT**

For supply of precast concrete piles of specified cross-section, the measurement shall be in metres of the length of piles ordered in writing by the Engineer measured from the head to the butt of the shoe. Reinforcement in precast concrete piles shall not be measured separately for payment as it is deemed to be included in the cost of pile.

For cast-in-situ driven and bored concrete piles of specified cross-section, the measurement shall be the length in metres of the accepted pile that remains in the finished structure complete in place. Reinforcement in cast-in-situ driven and bored concrete piles shall be measured in kg separately for payment.

For installation of the pile, i.e. by driving in the case of precast concrete and cast-in-situ driven piles, and by boring in the case of cast-in-situ bored piles the measurement shall be the length in metres that remains in the finished structure complete in place.

For steel liners/casing shown on the drawings to be permanently left in place, the measurement shall be by weight in tones that remains in the finished structure complete in place, limited to that shown on drawings or ordered by the Engineer.

For the pile cap, the quantity of concrete shall be measured in cubic metres, while reinforcement in pile cap shall be measured in tones/kg as specified.

**(4) PAYMENT**

The contract unit rate shall be the full and the final compensation to the Contractor for Installation of precast concrete piles. The cost of reinforcement in precast concrete piles shall be deemed to be included in the quoted rate for piles.

The contract unit rate shall be the full and the final compensation to the Contractor for all expenditures incurred by the Contractor for incidentals and for doing all the works

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involved in driving, placing filling materials for cast- in-situ or driven piles, cutting off piles as specified in this specification in addition to those specified in Clause 112.

Reinforcement in cast-in-situ driven and bored piles shall be paid at the contract unit rate as specified in Section 800.

Permanent steel liners shall be paid at the contract unit rate. The contract unit rate shall be the full and the final compensation to the Contractor for, fabrication and placing the steel liner to the required depth as shown on the drawings and as ordered by the Engineer in addition to those specified in Clause 112.

Concrete and reinforcement in pile cap shall be paid separately at the contract unit rate as specified in the contract.

### 1514. BAMBOO PILE

Bamboo piles of required size and length shall be made and driven at the required location for protection of river banks from erosion. Bamboo piling is a low cost but effective technology to be used for river training works. Bamboo being easily available in Terai region of Nepal, it is frequently used for river training of rivers flowing through plain Terai areas. Because of low cost and easy access, bamboo piling is effectively used during flood fighting in Terai Rivers.

#### (1) Materials

Bamboo piles of required diameter and length shall be prepared from the selected straight, sound and strong bamboo having required strength and moisture content. The moisture content shall not be more than 12%. Borer attack and decay in the culms shall not be permitted. Splits/cracks and blue stains are also not permissible as these defects affect strength properties.

#### (2) Bamboo Pile Driving

Before actual pile driving, piles of required size and length shall be prepared from the selected bamboos. Pointing edge of each bamboo pile shall be prepared in order to make the driving easy and comfortable. Pile lines shall be marked on the site and pile driving shall be processed at the designed interval with the help of wooden hammer or Monkey hammer or Water jet as prescribed in the contract. Iron cap shall be used while driving piles using wooden hammer or monkey hammer in order to protect the pile head from being teared. If the ground formation is hard, and hammering method is not feasible to drive the length up to the designed depth Water jetting method shall be used. In all cases, the depth of pile below ground level and that above ground level shall be maintained in order to protect the river banks as designed.

#### (3) Bamboo Fabric/ chachari

Bamboo fabric or bamboo chachari required to be used with bamboo piling shall be prepared of required size and dimension as per design from the bamboos approved by the Engineer. Bamboo chachari shall be installed along with bamboo piles using Nails and SWG GI wire as required.

#### (4) Measurement

Making of bamboo piles shall be measured in meter or number as specified in the contract or on the drawing. Driving of bamboo piles including supply of material and making shall be measured in meter or number as specified in the contract or on the drawing. Bamboo fabric/chachari shall be measured in Sqm.

**(5) Payment**

Payment of making bamboo piles, driving of bamboo piles including supply of material and making, bamboo fabric/chachari shall be made as per unit rate specified in the contract, which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

**1515. PORCUPINE****(1) General**

Porcupines are a form of permeable structure designed to reduce flow velocity and trap sediment. They have pole-like projections in all directions, resembling a porcupine with its quills sticking into the air. Porcupines can be used in a line forming a spur into a river, as silting aprons for larger spurs, and in a longitudinal line along an embankment. They are used as flood control structures and for river bank and bed protection as these function as bank protection, screens, spurs, or dampeners. The structures are flexible, which ensures stability against extreme water forces and even earthquakes. Porcupines reduce the flow velocity, intercept and break eddies formed by floodwater, and fill up scour holes with silt. Porcupines increase the roughness of the channel thereby deflecting the eroding current away from the bank.

Originally porcupines were made of timber or bamboo but these have a limited life span. The use of wooden and bamboo is replacing the RCC porcupine. Porcupines can be constructed in two shapes, tetrahedral and prismatic.

**(2) Scope**

This section comprises construction of concrete porcupines of different sizes and different grade of concrete. Bamboo Porcupine driven up to the scour level and Bamboo porcupines anchored with gabion works for the protection of bank against erosion and scour. Porcupines can be constructed as screens, spurs, or dampeners.

**(3) Construction of Porcupines**

**Porcupines used as spurs** (bars across) shall be aligned at 2–5° upstream of the flow. Spurs shall be single, double, or triple rows as mentioned in the drawing based on the velocity of flow, the width of the bank line channel, and the spacing between spurs. The porcupines during construction of spur shall be placed so that they touch each other at the base, and with the lines staggered if there are multiple rows. The spur shall extend from the highest flood level line to the deepest scour point of the bank line channel plus a marginal distance as a factor of safety. The spurs shall be extended to link up with the continuous non-submerged river bank or road – above the highest flood level – to avoid out flanking. The spacing between the rows of spurs shall be close to avoid formation of lagoons in between. When the curvature of the eroding bank is sharp and the flow velocity is high, porcupine spurs shall be placed less than 10 m apart.

**Porcupine dampeners** shall be laid in a row along the river bank functioning similar to revetment at spacing as specified in the drawing (generally 3m c/c in incase of 3m long concrete members of porcupine and 2m c/c in case of 2m long concrete members of porcupine). Rows of porcupine dampeners which depend upon the depth of flow shall be as specified in the drawings (generally 2 rows on either side of toe for flow depth less than 3m and more rows at specified spacing upto flood level for depth of flow more than 3m).

**Porcupine Screen** which is constructed for the closure of the secondary channel shall

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be constructed in 5 to 9 rows or as specified in the drawing at the spacing of 2 or 3 m c/c depending upon the length of the members of the porcupines. Porcupine screens shall be constructed to cover a part or whole width of the secondary channel as specified in the drawing. If screen is constructed to cover whole width of the secondary channel, it shall be extended one third of the width of the channel on either side of the channel.

### (a) Concrete Porcupine

Concrete porcupine shall be constructed in tetrahedral shape consisting of 6 members of specified length and size (generally 3m\*0.1m\*0.1m or 2m\*0.1m\*0.1m) made of Reinforced concrete of specified grade. The quality of concrete ingredients and strength of concrete shall be as specified in section 800. Though quality control of RCC struts is difficult because each strut cannot be tested separately, a rebound hammer shall be used to test the uniformity of strength of struts (member of concrete porcupine) throughout.

### (b) Bamboo Porcupine

Bamboo porcupine used for this purpose shall be made of bamboo free from defects and test complying to IS 6874:2008. Bamboo porcupines shall be made of 3 to 6 m long bamboo of 75 mm diameter or as specified in the drawing. Generally, locally available bamboos of girth 20 cm to 30 cm shall be used for the porcupines. The larger girth of 25 cm to 30 cm shall be used for the main members, whereas, the smaller girth of 20 cm to 25 cm shall be used for bracings. If suitable sizes are not available, use of bamboos of girth smaller than the specified shall be used if permitted by the Engineer, provided it may not significantly affect the overall result. Main vertical members of bamboo porcupines shall be driven possibly up to scour depth by hammering or by water jetting as specified in the contract.

Though bamboo porcupines are not so durable as RCC porcupine, they being low cost alternatives to erosion/bank protection, are frequently used for temporary bank protection during emergency due to floods owing to easy availability, ease of construction, fast workability and low construction cost.

### (c) Bamboo Porcupine anchored with gabion

Bamboo porcupines in bamboo porcupines anchored with gabions shall be same as specified in section 1514(b) above. However, main vertical members shall not be driven. Assembled porcupines shall be laid in position at site being anchored with toe gabions to prevent from displacement during flood. Porcupines shall be tied with the toe gabions using SWG wire, D-bolt and Cable rope of required quality and dimensions. Quality of Gabion works i.e. GI box and boulder shall be as specified in relative section of this specification.

## (4) Measurement and Payment

Concrete porcupine, Bamboo porcupine and bamboo porcupine anchored with gabions shall be measured in set or number as specified in the contract or on the drawing.

Payment of Concrete porcupine, Bamboo porcupine and bamboo porcupine anchored with gabions shall be made as per unit rate specified in the contract, which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1516. GEOBAG

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### (1) Scope

This section consist of providing, filling and laying geobags of required size as specified in the contract or on the drawing for bank revetment and spur construction in order to protect bank from erosion and scour.

### (2) Construction

Geobag bank revetment or spur shall be constructed as per the design drawing. Geobags filled with approved quality of sand and stitched properly shall be laid on single or multiple layers based on the velocity of flow as specified. Generally, geobags engaged in nylon/ polypropylene rope net shall be of single layer and thickness of geobag revetment shall be more than the thickness of boulder revetment. Filter material for geobags revetment is not necessary. However, filter materials if specified to be used shall be considered where safety for removal of material in between the bags shall have to be ensured.

### (3) Quality of Materials

Sand to be used for filling geobag shall be free from silt and clay. It shall be of desired quality as specified in relevant section of this specification. Specification of Non-woven geobag of size (1m\*0.7m) shall be:

Material and make: Non-woven Geo Bag should be made of virgin material and should not be made of recycle material. Needle punched, staple fiber, high elongation, non-woven PET Geo Textile should resist Ultraviolet, rooting and biological degradation, naturally encountered acid and alkalis.

Mass (GSM): As per ASTM: D 5261 = 300 gm/m<sup>2</sup>

Wide width Tensile Strength (Both Direction): As per ASTM: D4595 = 9.00 KN/M

Elongation (Both direction): As per ASTM D 4595 = 50%

Static Puncture Strength: As per ASTM D 6241 = 1400N

AOS (Apparent Opening Size): As per ASTM D 4751 =100 micron

Permittivity: As per ASTM D 4491 = 1.25

UV Resistance @500 hrs. : As per ASTM D 4355 (TYP) =70%

Trapezoidal Tear Strength: As per ASTM D 4533 = 340N

Volume of filled bag = 0.07 m<sup>3</sup>

Weight of filled bag = 126 Kg

Stitching: Ring Spun Yarn stitches with 2500-3500 denier (PET/PP): Double line chain stitch with overlap with stiches along the edges @ minimum 15 stitches/100mm

### (4) Measurement and Payment

Geobags laying and filling works shall be measured in number of bags.

Payment of Geobags laying and filling works shall be made as per unit rate specified in the contract, which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1517. SANDBAG/CEMENT BAG

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### (1) Scope

This section comprises filling of sand bags and laying in position for bank protection against erosion and scour during flood fighting. Sand/Cement bags are simple, local, low cost materials which have appreciable and effective use during time of emergency floods as revetment, filling materials for fencing and embankment raising. As sand bags have short life, these should not be used for long term flood protection measures.

### (2) Construction

Size of the sand bags shall be 75 cm (30 inch) high, 50 cm (20 inch) wide and 10 cm (4 inch) thick and contain about 1.25 cubic feet sand. Sandbags bank revetment shall be constructed as per the design drawing. Sandbags filled with approved quality of sand and stitched properly shall be laid on single or multiple layers based on the velocity of flow as specified. Generally, Sandbags encaged in nylon/ polypropylene rope net shall be of single layer and thickness of geobag revetment shall be more than the thickness of boulder revetment. The bags should be about one-half full and tied near the top so that the sand can move easily. Overfilled bags and bags tied too low lead to gaps in the bund or wall, which allows water to seep through. Filter material for Sandbags revetment is not necessary. However, filter materials if specified to be used shall be considered where safety for removal of material in between the bags shall have to be ensured.

Filling sandbags usually shall be a two-person operation. One member of the team shall hold the bag on the ground slightly in front of his or her spread feet and the second shall shovel the sand into the bag. The first layer of bags shall be placed lengthwise on the bund (parallel to the flow), lapping the bags so that the filled portion of one bag lies on the unfilled portion of the next, with the untied open end of the bag facing downstream. Adjacent rows or layers shall be offset by one half bag length to eliminate continuous joints.

### (3) Quality of Materials

Sand to be used for filling sandbag shall be free from silt and clay. It shall be of desired quality as specified in relevant section of this specification. Sand bags should be new and free from any sort of wear and tear.

### (4) Measurement and Payment

Sandbags laying and filling works shall be measured in number of bags.

Payment of Sandbags laying and filling works shall be made as per unit rate specified in the contract, which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1518. NYLON ROPECRATE

### (1) Scope

This section comprises supplying and delivery of Nylon Rope crates of specified size with specified mesh made from specified nylon ropes. Nylon Rope crates shall be used for emergency flood fighting. Nylon boxes filled with sand bags, shall be launched into flowing water next to the bank being eroded during floods. This will help to prevent toe erosion by lowering flow velocity and inducing siltation. This eventually deflects the flow away from the bank and protect the bank from being eroded.

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### (2) Construction

Constructed nylon crates of specified dimension shall be supplied for use during flood fighting in large rivers especially in plain (Terai) area. Size of the nylon crates shall be 6m\*3m\*0.75m having rectangular mesh 20cm\*20cm made from 8mm dia nylon rope or 3m\*1.05m\*1.05m having rectangular mesh 15cm\*15cm made from 4mm dia nylon rope as specified in the BOQ or on the drawing.

### (3) Quality of Materials

Nylon crate shall be new, made from original material and shall not be woven using recycled materials.

### (4) Measurement and Payment

Supply and Delivery of Nylon crate of required dimensions shall be measured in number of boxes.

Payment of Supply and Delivery of Nylon crate shall be made as per unit rate specified in the contract, which shall be full and final compensation for the cost of compliances of all requirements specified in Clause 112.

## 1519. ARTICULATING BLOCK (AB) FABRIC FORMED CONCRETE LINING

### (1) General

Articulating Block Mats form cable-reinforced concrete block mattresses that resist erosive forces. They are often constructed where a revetment is exposed to frontal attack by wave action.

AB Mats are typically used to protect coastlines, canals, rivers, lakes, reservoirs, underwater pipelines, bridge piers, and other marine structures from propeller wash, ship wakes, wind waves, currents, and high velocity flows. They are also used in environmental construction for landfill caps, down chutes, and collector channels.

### (2) Material

Articulating Block mattress consists of a series of compartments linked by an interwoven perimeter. Grout ducts interconnect the compartments, and high strength revetment cables are installed between and through the compartments and grout ducts. Once filled, the AB Mats become a mattress of pillow-shaped, rectangular concrete blocks. The interwoven perimeters between the blocks serve as hinges to permit articulation. The cables remain embedded in the concrete blocks to link the blocks together and facilitate articulation. Some relief of hydrostatic pressure is accomplished through the filtration bands formed by the interwoven perimeters of the blocks.

The fabric forms shall be composed of synthetic yarns formed into a woven fabric. Polyester yarns shall be used in the manufacture of the fabric. The forms shall be woven with a minimum of 50% textured yarns (by weight). Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. Each layer of fabric shall conform to the physical, mechanical and hydraulic requirements Mean Average Roll Values listed in Table 15.21. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties. The material property requirements of Articulating Block Fabric are listed below;

**Table 15.20 Typical Dimensions and Weight**

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Product and sizes	AB400	AB600	AB800	AB1000	AB1200
Average Thickness, in (mm)	4 (102)	6 (152)	8 (203)	10 (254)	12 (305)
Mass per unit area, lb/ft <sup>2</sup> (kg/m <sup>2</sup> )	45 (220)	68 (330)	90 (440)	113 (550)	135 (661)
Mass per block, lb (kg)	88 (39.8)	188 (85.2)	325 (148)	563 (255)	844 (382)
Nominal Block Dimension, in (mm)	20 x 14 (508 x 356)	20 x 20 (508 x 508)	20 x 26 (508 x 660)	30 x 24 (762 x 610)	30 x 30 (762 x 762)
Concrete Coverage ft <sup>2</sup> /yd <sup>3</sup> (m <sup>2</sup> /m <sup>3</sup> )	75 (9.1)	50 (6.1)	38 (4.6)	30 (3.6)	25 (3.0)
Shear Resistance, lb/ft <sup>2</sup> (kg/m <sup>2</sup> )	8 (203)	10 (254)	12 (305)	14 (356)	16 (406)

Table 15.21 Property Requirements – Articulating Block Fabric

	Test Method	Units	MARV#
<b>Physical Properties</b>			
Composition of Yarns	Not Applicable		Polyester
Mass Per Unit Area (single-layer)	ASTM D 5261	g/m <sup>2</sup>	>200
Mass Per Unit Area (double-layer)			>400
Thickness (single-layer)	ASTM D 5199	mm	0.35
Mill Width (Woven)	Not Applicable	m	3.00
<b>Mechanical Properties</b>			
Wide Width Tensile Strength – MD   TD	ASTM D 4595	kN/m	50   50
Wide Width Elongation at Break - MD   TD	ASTM D 4595	%	>10   >10
Trapezoidal Tear Strength - MD   TD	ASTM D 4533	N	350   350
CBR Puncture Strength	ASTM D 6241	N	5100
<b>Hydraulic Properties</b>			
	Test Method	Units	MARV# Range
Apparent Opening Size (AOS)*	ASTM D 4751	mm	< 0.8
Water Flow Rate*	ASTM D 4491	l/m <sup>2</sup> /min	> 1000

\* Handling may vary the above properties in its application.

# MARV stands for Minimum Average Roll Value and is calculated as the average minus two standard deviations. Statistically, it yields approximately 97.5% degree of confidence that any samples taken from quality assurance testing will meet or exceed the values described above.

Articulating Block mattress shall consist of double-layer woven fabric joined together by spaced, interwoven fabric into a matrix of rectangular compartments. Cords shall connect the two layers of fabric at the center of each compartment. The cords shall be interwoven in two sets of four cords each, one set shall cross from the top layer to the

  
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bottom layer and the other from the bottom layer to the top layer. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

Fabric form compartments shall each have six ducts, two on each of the long sides and one on each of the short sides to allow passage of the fine aggregate concrete between adjacent compartments. The fine aggregate concrete filled, cross-sectional area of each duct shall be no more than 10 percent of the maximum filled cross-sectional area of the block lateral to the duct.

Articulating Block consists of Cables present in Longitudinal or Both directions which is designed as per the site conditions. Cables shall be installed in the longitudinal direction between the two layers of fabric. Two longitudinal cables shall pass through each compartment in a manner which provides for the longitudinal and lateral binding of the finished articulating block mat. The cables shall enter and exit the compartments through opposing ducts. All longitudinal cables within each filled concrete block shall be completely embedded in the fine aggregate concrete.

Mill widths of fabric shall be a minimum of 3.0 m. Each selva edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 34 mm by adding a minimum of 6 warp yarns to each selva construction. Mill width rolls shall be cut to the length required, and the double-layer fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels with sewn seams on not less than 2.9 m centers.

Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 17 kN/m when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 6.3 mm to 19 mm apart. Each row of stitching shall consist of 8 to 14 stitches per 5.0 cm. Thread used for seaming shall be polyester. The fabric form shall be customized in factory as per site geometry or profile and then shall be supplied at site in the form of panels consisting of multiple mill width of the fabric form along with baffles and cables installed inside the fabric form. Each such panel shall be connected with the adjacent panel by using Industrial Zipper. In-situ stitching or sewing between panels shall not be allowed. The apron shall be integrated with large sized armor unit at the riverside end to facilitate launching, if any.

Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 350 N when tested in accordance with ASTM D 4632.

Cables in AB mat shall be galvanized steel cables of minimum 6 mm diameter and the breaking strength of the cable shall not be less than 30 kN. The cables shall be laid in both direction of the mat when it is used as launching apron and the cables shall be laid in one direction when the mat is used for the protection of slope or river bank.

Materials manufactured in India shall be preferred for this work. For this purpose assembling of materials imported from abroad and producing the mattress shall not be allowed.

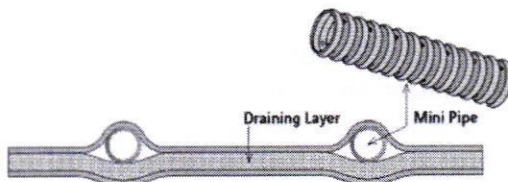
Fine aggregate concrete shall consist of a proportioned mixture of Portland-Pozzolana

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cement, fine aggregate (sand) and water. The consistency of the fine aggregate concrete delivered to the concrete pump shall be proportioned and mixed as to have a flow time of 9-12 seconds when passed through the 19-mm orifice of the standard flow cone that is described in ASTM C 939. Additional Pozzolana and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and shall be determined by the ready-mix manufacturer using the above referenced flow cone. Fly ash can be used to reduce the cement consumption.

The fabric forms shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873.

**Drainage behind TechRevetment lining:** One layer of multi-linear geocomposite drainage with mini pipes shall be placed behind the AB TechRevetment lining from HFL to LWL level for better drainage during rapid drawdown.



Specification of multi-linear geocomposite drainage with mini pipes shall be as under:

**Table 15.22 Specification of multi-linear geocomposite drainage with mini pipes**

Characteristics Value	Standards	Reference	Value	Unit
<b>Mechanical characteristics</b>				
Mass per unit area	NF EN 9864	Geotextile	369	g/sq.m
Thickness	NF EN 9863 -1	Under 2 kPa	4.0	mm
		Under 20 kPa	3.2	
Tensile strength	NF EN ISO 10319	Machine direction	13.9	kN/m
		Cross direction	13.9	
Tensile elongation	NF EN ISO 10319	Machine direction	63	%
		Cross direction	63	
Pyramidal puncture	NF G 38-019		1.8	kN
Dynamic perforation	NF EN ISO		<4	mm
CBR resistance	NF EN ISO		3.4	kN
<b>Mini-pipes characteristics</b>				
Diameter	NF EN 61386-1	Outside diameter	19	mm
Pipe stiffness at 5% deflection	ASTM D2412	0	4000	kPa
Spacing of mini-pipes	1 mini-pipe every one metre widthways			
<b>Hydraulic characteristics</b>				
Opening size	NF EN ISO	Filter layer	77	µm
Water permeability	NF EN ISO	Filter layer	70	l/s/m2



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In-plane flow capacity (mini pipes)	NF EN ISO 12958	Gradient i=0.1	Under 20 kPa	0.18	l/s/m		
			Under 100 kPa	0.18			
			Under 400 kPa	0.18			
				Under 400 kPa during		0.18	
		Gradient i=0.3	Under 20 kPa	0.32	l/s/m		
			Under 100 kPa	0.32			
			Under 400 kPa	0.32			
				Under 400 kPa during		0.32	
		Gradient i=1	Under 20 kPa	0.70	l/s/m		
			Under 100 kPa	0.70			
Under 400 kPa	0.70						
		Under 400 kPa during 100h		0.70			

One layer of non-woven geotextile filter fabric shall be placed behind the AB TechRevetment lining after LWL till the launching apron length. The non-woven geotextile filter fabric shall be made from polypropylene. The minimum mass of the non-woven geotextile shall be 203 grams per sq.m.

**(3) Anchorage with TerraAnchor:**

The revetment mattress shall be anchored at the top by excavating a trench and laying the mattress followed by filling the trench with M15 grade of concrete. The cables of the revetment mattress shall be anchored into the trench using driven and stressed soil anchors of 3m length and minimum 2MT capacity. The technical specification of the anchor shall be as under;

**Stealth Anchor**

S.G. Iron casting confirming to IS 1865:1991

Length: 160mm

Width: 57mm

Height: 50mm

Galvanization: Minimum 500 grams per Sqm

**Anchor Strand Wire**

Construction of strand: 7X19 steel core

Diameter of wire: Minimum 8mm

Ultimate Tensile strength: Minimum 35 KN

Working load: Minimum 23 KN

Galvanization: Minimum 220 grams per Sqm

**(4) Measurement and Payment**

The payment for AB mattress, multi linear geocomposite drainage and non-woven geotextile shall be made based on the surface area of the materials supplied for laying

  
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on the surface of the slope including anchorage, overlaps and apron. The surface area shall be measure in 'Sqm'.

The payment for the fine aggregate concrete shall be made based on the volume of concrete inside the mattress including the cost of cement, fly ash (if any), fine aggregate, machinery required, tools and plants.

The Payment for AB mattress measured in Sqm, including the cost of fine aggregate concrete shall be made based on the surface area of the mattress if analysis includes both items together.

**1520. FILTER POINT (FP) FABRIC FORMED CONCRETE LINING**

**(1) General**

Filter Point linings with filtration point (drains) provide an erosion resistant, permeable concrete lining having a cobbled surface and a relatively high coefficient of hydraulic friction in order to reduce water velocity and wave run-up. The spacing of the filter points determines the linings thickness and weight, while the specially designed filter points relieve hydrostatic pressure and reduce applied stress to the fabric form during pumping.

The fabric forms shall consist of woven double-layer, open salvage fabric joined into panels. Fabric shall be woven of high-tenacity, continuous multifilament polyester of which a minimum of 50%, by weight, shall be textured yarn. Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. The fabric forms shall conform to the physical, mechanical and hydraulic requirements as listed in Table 15.24 and reported by an independent geotextile laboratory within ninety (90) days of date of manufacture. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties. The material property requirements of Filter Point Fabric are listed below.

**Table 15.23 Typical Dimensions and Weight**

Product and sizes	FP220	FP300	FP400	FP600	FP800	FP1000	FP1200
Average Thickness, in (mm)	2.2 (56)	3 (76)	4 (102)	6 (152)	8 (203)	10 (254)	12 (305)
Mass per unit area, lb/ft <sup>2</sup> (kg/m <sup>2</sup> )	25 (121)	34 (165)	45 (220)	68 (330)	90 (440)	113 (550)	135 (661)
Concrete Coverage ft <sup>2</sup> /yd <sup>3</sup> (m <sup>2</sup> /m <sup>3</sup> )	136 (16.6)	100 (12.2)	75 (9.1)	50 (6.1)	38 (4.6)	30 (3.6)	25 (3.0)
Filter Point Spacing, in (mm)	5 (127)	6.5 (165)	8 (203)	10 (254)	12 (305)	14 (356)	16 (406)

**Table 15.24 Property Requirements – Filter Point Fabric**

	Test Method	Units	MARV#
<b>Physical Properties</b>			



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Composition of Yarns	Not Applicable		Polyester
Mass Per Unit Area (single-layer)	ASTM D 5261	g/m <sup>2</sup>	>200
Mass Per Unit Area (double-layer)			>400
Thickness (single-layer)	ASTM D 5199	mm	0.35
Mill Width (Woven)	Not Applicable	m	3.00
<b>Mechanical Properties</b>			
Wide Width Tensile Strength – MD   TD	ASTM D 4595	kN/m	50   50
Wide Width Elongation at Break - MD   TD	ASTM D 4595	%	>10   >10
Trapezoidal Tear Strength - MD   TD	ASTM D 4533	N	350   350
CBR Puncture Strength	ASTM D 6241	N	5100
<b>Hydraulic Properties</b>			
	<b>Test Method</b>	<b>Units</b>	<b>MARV# Range</b>
Apparent Opening Size (AOS)*	ASTM D 4751	mm	< 0.8
Water Flow Rate*	ASTM D 4491	l/m <sup>2</sup> /min	> 1000

\* Handling may vary the above properties in its application

# MARV stands for Minimum Average Roll Value and is calculated as the average minus two standard deviations. Statistically, it yields approximately 97.5% degree of confidence that any samples taken from quality assurance testing will meet or exceed the values described above.

Filter Point Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven filter points to form a concrete lining with a deeply cobbled surface appearance. Filter points shall be formed by interweaving the double-layer fabric to form water permeable drains and attachment points for the control of concrete lining thickness. The interweaving of the fabric layers shall form an area of double density, high strength, and single-layer. All filter points shall be cross shaped and shall have twill weave centers designed to function as drains to relieve hydrostatic uplift pressure. The average thickness shall be as per design.

Mill widths of fabric shall be a minimum of 3.0 m. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 34 mm by adding a minimum of 6 warp yarns to each selvage construction. Mill width rolls shall be cut to the length required, and the double-layer fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels with sewn seams on not less than 2.90 m centers.

Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 6.3 mm to 19 mm apart.

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Each row of stitching shall consist of 8 to 14 stitches per 5.0 cm. Thread used for seaming shall be polyester. The fabric form shall be customized in factory as per site geometry or profile and then shall be supplied at site in the form of panels consisting of multiple mill width of the fabric form along with baffles. Each such panel shall be connected with the adjacent panel by using Industrial Zipper. In-situ stitching or sewing between panels shall not be allowed.

Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 350 N when tested in accordance with ASTM D 4632.

The fabric forms shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873.

Materials manufactured in India shall be preferred for this work. For this purpose assembling of materials imported from abroad and producing the mattress shall not be allowed.

Fine aggregate concrete shall consist of a proportioned mixture of Portland-Pozzolana cement, fine aggregate (sand) and water. The consistency of the fine aggregate concrete delivered to the concrete pump shall be proportioned and mixed as to have a flow time of 9-12 seconds when passed through the 19-mm orifice of the standard flow cone that is described in ASTM C 939. Additional Pozzolana and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and shall be determined by the ready-mix manufacturer using the above referenced flow cone. Fly ash can be used to reduce the cement consumption.

**Drainage behind TechRevetment lining:** One layer of non-woven geotextile filter fabric shall be placed behind the TechRevetment lining. The non-woven geotextile filter fabric shall be made from polypropylene. The minimum mass of the non-woven geotextile shall be 203 grams per sq.m.

### (2) Measurement and Payment

The payment for FP mattress and non-woven geotextile shall be made based on the surface area of the materials supplied for laying on the surface of the slope including anchorage, overlaps and apron. The surface area shall be measure in 'sq.m'.

The payment for the fine aggregate concrete shall be made based on the volume of concrete inside the mattress including the cost of cement, fly ash (if any), fine aggregate, machinery required, tools and plants.

The Payment for FP mattress measured in Sqm, including the cost of fine aggregate concrete shall be made based on the surface area of the mattress if analysis includes both items together.

## 1521. EROSION CONTROL MAT

### (1) Scope

The work covers the use of geosynthetic mats for control of erosion of slopes including

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supplying and laying the mat, spreading soil and seeding to promote the design of vegetation, as per design, drawing and these specifications.

(2) **Material and Strength Requirements**

Geosynthetic mat shall be a three-dimensional structure consisting of UV stabilized non-degradable polypropylene, polyethylene, nylon or similar polymer fibers that are extruded or heat bonded at the contact points to provide a dimensionally stable matrix for soil erosion protection. A tension element, i.e., a reinforcing element like Geogrid or steel wire mesh shall be included along with the three dimensional polymeric mats to provide strength against erosive forces, if specified in the contract

The tensile strength requirements for non-reinforced and reinforced three dimension geosynthetic mat shall meet the minimum requirement as specified in Table 15.25 and Table 15.26 respectively.

(3) **Installation**

Prior to lying of geosynthetic mat on the slope, the surface shall be properly prepared, cleaned and dressed to the specified lines and levels as shown on the drawings. Specified trench keys along the crest and at the bottom of slope area shall be provided to fix the geosynthetic mat in the ground. In case the soil is not fertile, it shall be mixed with suitable amount of fertilizer or seeds.

**Table 15.25: Tensile Strength Requirement for Normal (Non-Reinforced) Three Dimensional Geosynthetic Mat for Erosion Control Application (Less Severe Environmental Condition)**

Property	Test method	Units	Minimum Average Roll value
Tensile strength requirement (For slopes less than 60°)	ASTM D 5035	kN/m	2
Ultraviolet stability at 500h, Retained strength percentage with respect to original strength	ASTM D 4355	%	80
Thickness	ASTM D 6525	mm	6.5
Mass per unit area	ASTM D 3776	gm/m <sup>2</sup>	350

**Table 15.26: Tensile Strength Requirement for Reinforced Three Dimensional Geosynthetic Mat for Erosion Control Application (Severe Environmental Conditions)**

Property	Test method	Units	Minimum average Roll value
Tensile strength requirement	ASTM D 5035	kN/m	10
			35
Ultraviolet stability at 500h, Retained strength percentage with respect to original strength	ASTM D 4355	%	80
Thickness	ASTM D 6525	mm	12
Mass per unit area of the composite	ASTM D 3776	gm/m <sup>2</sup>	500

The work of laying the mat shall begin at the top of the slope providing anchor blankets

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in a 300 mm deep and 300 mm wide trench and anchoring with staples/pins. The mat shall then be unrolled down the slope in the machine direction. The blanket shall not be stretched but shall have full contact with the soil. The blanket shall be anchored using staples or stakes.

Edges of adjacent parallel rolls shall be overlapped by approximately 100 mm to 120 mm and anchored with staples at 600 mm to 800 mm spacing depending on the slope. When blankets have to be spliced, the upper blanket end shall be placed over lower blanket end (shingle style) with 300 mm overlap and anchoring with two staggered rows of staples at 300 mm spacing.

A minimum cover of soil shall be spread followed by spreading the seeds and fertilizer.

In the absence of rain, blankets shall be regularly watered for viable growth till vegetation sustains on its own.

If any damage due to heavy downpour is noticed, suitable corrective measures shall be taken immediately.

Gully formations, if any, shall be suitably corrected depending upon the site condition.

The treated area shall be protected from the movement of cattle (goat, sheep & cow).

Grazing shall be avoided till the vegetation sustains on its own

### (4) Measurement and Payment

The geosynthetic mat shall be measured in square meter as per planned dimensions with no allowance for overlapping at joints, anchoring at toe and crest of the slope.

Geosynthetics mat shall be paid at the respective contract unit rate which shall be full and final compensation for the cost of compliances of all requirements specified in Clause, 1521 in addition to those specified in Clause 112.

## 1522. STEEL WIRE GRID

### (1) General

The Steel grid System is an innovative complete system for rockfall mitigation and slope consolidation works. The Steel grid System combines a high strength steel wire mesh geocomposite which is used in conjunction with anchor plates, specific U-bolts and mesh connectors. The Steel grid mesh is a composite of double twisted steel wire hexagonal mesh with high tensile strength steel cables, woven into the mesh during the manufacturing process.

The high level corrosion protection for the steel wire mesh and ropes and for the accessories makes the Steel grid System ideal for rockfall protection in all continental environments.

### (2) Material

High-strength reinforced composite steel wire mesh/panel with a minimum longitudinal tensile strength of 160 kN/m and puncture resistance of 130kN at maximum displacement of 45 cm, steel wire/rope/high strength rope shall be heavily Zn+5% Al Class A conforming to EN 10244-2 and mesh opening shall not be more than 125mm, including top and bottom support rope, lateral wire rope cable anchors at top and bottom, lacing wire rope, connection clips required to connect the nets and all accessories such as U-clamps, including safety, all other ancillary works, material etc, complete at the easily accessible location including top and bottom.

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Equivalent or Higher specifications product will Technically Evaluated and accepted.

For faster installation and better adherence over undulated slope face, high resistance geocomposite steel wire mesh/panel should be single composite product and mesh opening shall not be more than 125mm. The high resistance steel wire mesh geocomposite shall confirm properties indicated in Table 15.27. All tests on the mesh and lacing wire/wire rope must be performed prior to manufacturing the mesh.

**Table – 15.27: High Resistance Geocomposite Steel wire mesh/panel should meet the following minimum strength requirements:**

Sr. No.	Strength Parameter	Value (minimum)
01	Longitudinal Tensile Strength of High Resistance Geocomposite steel wire mesh/panel	160kN/m
02	Puncture Resistance of High Resistance Geocomposite steel wire mesh/panel	130kN at maximum displacement of 45 cm

\*\*\* The above parameters shall meet the requirements as per the test procedures defined in IS/ISO 17746.

### **Material Technical Performance Requirements:**

- a. The High Resistance Geocomposite steel wire Mesh/panel should have minimum tensile strength of 160kN/m in longitudinal direction as per the test procedures defined in ISO 17746.
- b. Under punch test with the standard / established procedure the system of High Resistance Geocomposite Steel wire mesh/panel should be able to bear minimum resistance of 130 KN with maximum displacement up to 45cm as per the test procedures defined in ISO 17746.

### **(3) Measurement and Payment**

The measurement shall be in Sq.m of Area of High Resistance Steel Wire Mesh Geocomposite supplied.

Payment shall be made as per contract unit rate as specified in the contract.

## **1523. SELF-DRILLING ANCHOR**

### **(1) General**

The Self Drilling Anchor system is comprised of a hollow threaded anchor bar with a sacrificial drill bit that performs drilling, anchoring and grouting in a single operation.

The SDA shall be designed and arranged in order to stabilize in-situ strata. The grout shall be made of OPC min. grade 43 & above with suitable admixtures. The exposed portion of SDA, nuts and bearing plates shall have corrosion protection coating as per project requirement.

Drilling shall be carried out by suitable equipment. Diameter of SDA shall be 32 mm with sacrificial drill bit of min. 76mm dia. The SDA shall be made of yield strength of min. 550 N/mm<sup>2</sup> and yield load of min. 230kN. The SDA rod shall be continuously threaded. For convenience of installation, appropriate arrangement (coupler) shall be made to connect two smaller lengths of SDA to achieve the required length.



  
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### (2) Installation

- (a) The SDA is driven in the required position with help of sacrificial drill bit at the bottom of the anchor bar which facilitates in drilling the hole. The diameter, length and spacing of SDA shall be as specified. Any more / lesser length or spacing of anchoring/nailing shall be carried out as per site condition and as directed by engineer-in-charge.
- (b) The grout is pumped through the hollow bar during the drilling process. Grouting shall be done by using OPC min. grade 43 & above along with addition of suitable admixture. Mixing shall be done along with potable water so as to form the cementitious paste.
- (c) The base plates of size (min.) 200mm x 200mm x 10 mm shall be placed at rock interface for tightening the nuts.
- (d) The fascia (if applicable) shall be installed in front and connected to the steel rods with base plate and nuts.

Following equipment deployed on site

- 1) Grout agitator
- 2) Compressor – 450 to 600CFM
- 3) Drilling equipment percussion/rotary type

Expansive plasticizing agent for cement grouts shall be used, typical brand name DR. FIXIT PIDICRETEAM is a shrinkage compensating grout admixture for pressure grouting.

### (3) Special requirement

The agency must have experience in working in steep slopes including surface anchoring for a depth of at least 3m. The agency should also have good experience in drilling and grouting works on steep slopes of more than 100m in height.

### (4) Measurement and Payment

The measurement of SDA shall be in running meter as specified in BOQ.

Payment shall be made as per contract unit rate as specified in the contract.

## 1524. ROCK FALL BARRIER

### (1) General

Rockfall barriers are made of high quality carbon steel or stainless steel, including steel wire rope net, steel ring net, tecco mesh, spider spiral rope mesh, chain link wire mesh and hexagonal wire mesh. With galvanized, powder coated or PVC coated surface, they're corrosion and rust resistant. The common rockfall barrier combination is steel wire rope net with chain link mesh, it can be used as active or passive rockfall barrier for slope or mountain protection to minimize the impact of natural disasters, such as landslide, debris flow and so on.

### (2) Material

#### Material Technical Performance Requirements:

The dynamic Rockfall Barriers shall be approved "Category A" barriers as per EAD (European Approval Document EAD 340059-00-0106(Previously known as ETAG 027)).

**Specification of The Materials To Be Used:**

The flexible rockfall barrier should have pass through the dynamic crash test as per EAD 340059-00-0106 (previously named as ETAG 027) by an independent institute for energy level of 1500KJ/3000KJ/5000KJ capacity in crash test and passed for a category "A" having residual height more than 50% of the nominal height. The flexible high resistance rock fall barrier should have kinetic energy absorption capacity (without any breakage) of 1500KJ/3000KJ/5000KJ and having an interception height of 5m/6m/7m.

The dynamic barrier shall consist of:

- Hot dip galvanized steel posts
- Interception structure made up of to catch the small debris material.
- Upper and lower longitudinal cables, upslope bracing cables, lateral bracing cables, ground cables and downslope bracing cables (if required) with a tensile strength not lower than 1770 N/mm<sup>2</sup>
- Energy absorbing system consisting of energy dissipating devices installed on the bracing cable or on the perimeter of the interception structure
- Connection of the cables by means of ferrules (pressed in the workshop) or U-bolt wire rope grips according to EN 13411.

The structure shall be suitable for installation on any type of terrain and slopes. All the metallic components shall be protected against corrosion with zinc galvanization in accordance with:

- Steel wire ropes according to EN 10264-2 (class A)
- Supporting structure (steel posts and base plates) protected by hot dip zinc coating according to EN ISO 1461
- Wire of the net according to EN 10244-2 (Class A)
- U-bolt wire rope grips hot dip zinc coated according to ASTM A153
- Shackles (if any) hot dip zinc coated according to EN ISO 1461
- Fasteners (bolts and nuts) hot dip zinc coated according to EN ISO 10684
- Anchor bars hot dip zinc coated according to EN ISO 1461
- Electroplated coatings for minor components according to EN ISO 4042.

**Materials shall confirm to following standards:**

- EAD 340059-00-0106(previously named as ETAG 027) – Dynamic Crash Test
- Barrier shall meet the quality certification standard UNI EN ISO 9001
- Cables – Tensile Strength shall not be less than 1770N/mm<sup>2</sup>
- Energy dissipaters - energy absorption by deformation
- EN 13411-5-Clamps/Ferrules / U bolt
- EN10264 –2-Steel wire rope Zn coating
- EN ISO 1461- Zn coating of Post and base plate

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- EN 10223-3 and EN 10244 -2 -Double Twisted Hexagonal Net tensile strength and Zn coating
- EN 10025 -2- Hot Rolled Products

The structure shall be suitable for installation on any type of terrain and slopes. All the metallic components shall be protected against corrosion. The system shall have energy dissipators/braking system which should be able to help dissipate the impact energy by deformation and not by friction.

### **Testing and Acceptance criteria for Quality Control:**

The Category A dynamic Rockfall Barriers shall be supplied along with the approved test certificate mentioning residual height and capacity and have passed dynamic impact test as per EAD 340059-00-0106(Previously named as ETAG 027).

### **(3) Measurement and Payment**

The rockfall barrier shall be measured in running meter.

Payment shall be made at contract unit rate as specified in the contract.

## **1525. RHOMBOIDAL WIRE ROPE PANEL/MESH**

### **(4) General**

The rockfall protection system shall be as per IRC Highway Research Board Special Report-23 to be used for high hazard locations and should have corrosion protection heavily Zn Class A coating, to prevent corrosion effect at rockfall protection system.

### **(5) Material Specifications**

Rhomboidal shaped cable/wire rope panels with a minimum tensile strength of 230kN/m and punch strength of 370kN with max. displacement of 35cm, heavily Zn class A coated conforming to EN 10244-2 with a suitable connection at each intermediate and end junctions including top and bottom support rope, lateral wire rope cable anchors at top and bottom, lacing wire rope required to connect the nets and all accessories such as U-clamps, including safety, all other ancillary works, material etc, complete at the easily accessible location including top and bottom.

Equivalent or Higher specifications product will Technically Evaluated and accepted.

**Table – 15.28: The wire rope cable panel should meet the following minimum strength requirements:**

Sr. No.	Strength Parameter	Value (minimum)
01	Tensile Strength of cable Panel	230KN/m
02	Puncture Strength of Cable Panel	370 KN at maximum displacement of 34cm

\*\*\* The above parameters shall meet the requirements as per the test procedures defined in IS/ISO 17746.

### **Material Technical Performance Requirements:**

- a) The established system should be able to increase the bearing capacity during punch test / any accepted method of testing material. Under punch test with the standard /



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Secretary

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established procedure the system of wire rope cable panel with suitable connection at each intermediate and end junction should be able to bear minimum resistance of 370 KN with maximum displacement up to 34cm as per the test procedures defined in IS/ISO 17746.

- b) The wire rope cable panel with suitable connection at each intermediate and end junction should have minimum tensile strength of 230kN/m as per the test procedures defined in IS/ISO 17746.

### (6) Measurement and Payment

The measurement shall be based on Sq.m of Area of cable/wire rope panels supplied.

Payment shall be made at contract unit rate as specified in the contract.