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5 **SLOPE PROTECTION (WHEREVER REQUIRED)**

5.1 **SCOPE OF WORK**


- i) Work under this Chapter includes all labour, materials, equipment and services required to protect the slopes either excavated or those of embankments and backfills.
- ii) This Chapter covers the following items:
 - a) Rip rap,
 - b) Rock paving,
 - c) Gabions,
 - d) Masonry walls,
 - e) Anchor bolt and shotcrete for slope protection,
 - f) Polyethylene sheet cover,
 - g) Topsoil and seeding,
 - h) Landscaping.
- iii) The Contractor shall place the various items specified herein as protection to slopes or lining to ditches to the lines and thicknesses, and in the locations shown on the Construction Drawings, or as directed by the Project Manager.
- iv) Material specifications and measurement and payment for sprayed concrete, rock-bolt, wire mesh, and drainage work are specified in other Chapters of these Specifications.

5.2 **STANDARDS**

Slope protection work shall conform to the latest editions of the following Indian Standards:

- | | |
|----------|--|
| IS: 432 | Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement. |
| IS: 4826 | Hot-dipped galvanized coatings on round steel wires. |

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5.3 **SUBMITTALS**

The Contractor shall submit a Method Statement on how he intends to fulfil the Scope of Work under this Chapter and with a description of the materials that he intends to use. The Method Statement is subject to the approval of the Project Manager.

5.4 **RIP RAP**


5.4.1 **MATERIALS**

- i) Rip-rap specified in this Chapter shall be used for protection work.
- ii) Material required for rip-rap, and sand and gravel bedding shall be obtained and selected from required excavations or from quarries as approved by the Project Manager.
- iii) Bedding material shall consist of a pervious mixture of sand and gravel, well graded between 0.5 and 25 mm, with a mean diameter $d_{mean}=10$ mm. It shall not contain more than 5% of material passing IS Standard Sieve 75 μ (0.075 mm).
- iv) Rock for rip-rap shall be sound, dense, resistant to abrasion and weathering, and generally free from cracks, seams and holes. Angular rock fragments shall preferably be used. Well-rounded cobbles and boulders will not be accepted except on very flat slopes. The minimum dimension of any single rock shall not be less than one-fourth of its maximum dimension.
- v) If not otherwise directed by the Project Manager, rip-rap shall consist of rock particles having 25% by weight of at least 400 mm diameter, and 90% by weight of at least 200 mm diameter. Sand and rock dust may not exceed 5% of the total weight of the rip-rap material. Maximum size of boulder shall be limited to the nominal thickness of rip-rap.

5.4.2 **EXECUTION**

- i) The Contractor shall place the sand and gravel-bedding layer of 150 minimum thickness, or as indicated on the drawings, to the lines, grades and

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dimensions shown on the construction drawings. The material shall be placed moist and compacted as directed by the Project Manager.

- ii) Rip-rap shall be dumped in place or placed by backhoe. It need not be compacted, but shall be roughly graded to the specified thickness in such a way as to ensure that larger rock fragments are uniformly distributed, with the smaller rocks filling the remaining spaces. Pockets of small stones shall be removed and replaced with larger material such that the required grading is achieved. Placing operations shall be such that rip-rap layer is well keyed, uniform and dense.

5.5 **ROCK PAVING**


5.5.1 **MATERIALS**

- i) Fragments of rock for paving shall be selected from required excavation or quarries and shall have the same properties as rip-rap material. They shall be chosen such that they have a reasonably flat upper surface when laid. Stones for dry rock paving shall not have a round or spherical form and shall be of regular shape. Stones for rock paving in mortar shall be not less than 10 cm thick and not less than 100 cm² in area.
- ii) Bedding material for dry rock paving shall consist of a mixture of sand and gravel reasonably well graded between 0.5 and 25 mm.
- iii) Mortar for rock paving in mortar shall comprise 3 parts of clean fine aggregate and 1 part cement, and shall comply with the requirements specified in the Chapter "Concrete".

5.5.2 **EXECUTION OF DRY ROCK PAVING**

- i) The Contractor shall place dry rock paving on a bedding of sand and gravel of minimum thickness of 20 cm.
- ii) Rocks shall be hand placed in such a pattern that no continuous vertical or horizontal joints occur, and the spaces between the stones shall be filled with smaller rocks or gravel.

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- iii) The surface of complete paving shall be even with surface projections not exceeding 20% of the specified layer thickness.

5.5.3 EXECUTION OF ROCK PAVING IN MORTAR

- i) The Contractor shall place selected pieces of rock on a mortar bed and fill the joints with mortar. Experienced masons, duly qualified in their trade, shall perform the work.
- ii) Prior to placing, the rock shall be cleaned of all adherent soil, dust and earthy or organic impurities, and wetted sufficiently to saturate it, but leaving the surface in a damp condition.
- iii) Rocks shall be placed on a mortar bed of minimum thickness of 50 mm and carefully arranged in such a way that the minimum of voids remain between rocks, no continuous horizontal or vertical joints exist, and the largest rocks are evenly distributed.
- iv) After rock placing, the joints shall be completely filled with mortar. Splashing of exposed rock surfaces with mortar shall be avoided, and where splashing does occur, the surface of the rock shall immediately be cleaned down with a sponge and clean water.
- v) Finished surfaces shall be adequately protected against rainfall until the mortar has set. After setting, mortar shall be raked out to a depth of approximately 15 mm from the face of the rock, and the rocks sponged off along their edges. Wetted jute bags shall be used to cure the mortar for 3 days.
- vi) Joints and weep holes shall be provided in the locations and in accordance with the details shown on the Construction Drawings, or as directed by the Project Manager.

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5.6 GABIONS


5.6.1 MATERIALS

- i) Gabions (or wire crates) shall have a volume varying between 1 and 4 m³ depending on local requirement. They shall be rectangular in shape and constructed of double twisted galvanized mild steel wire formed into a hexagonally shaped mesh, of mesh area between 5,000 and 8,000 mm². Corners shall be reinforced with larger diameter galvanized wire.
- ii) Gabions shall be either prefabricated or assembled at the required place of installation, and then filled with cobbles or rock fragments.
- iii) The iron wire for gabion construction shall be hard drawn conforming to IS: 432 (Part II). The galvanized coating on the wire shall conform to IS: 4826. The wires shall have the following minimum diameter:
 - a) Net and tension rods 3 mm
 - b) Wires for corner reinforcement 5 mm
 - c) Seam wires 2 mm
- iv) Fill material shall comprise cobbles or rock fragments that are dense, sound and resistant to abrasion. Cobbles and rocks shall be free of cracks, seams and other defects, which could increase their susceptibility to destruction by erosive action. Individual cobbles or rock fragments shall be rounded and well graded in size between 120 and 200 mm. Flat rock fragments shall not be used.

5.6.2 EXECUTION

- i) Gabions shall be assembled, connected together, and filled at locations as shown on the Tender Drawings and as described herein.
- ii) Foundation surfaces upon which gabions are to be placed shall be reasonably smooth and even, with excessive high spots removed and voids filled with small rock fragments. Gabions to be placed at the toe of slopes shall be laid in a trench at least 250 mm deep.

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- iii) Gabions shall be secured in position by tying to adjacent gabions, and where laid on slopes, shall be fixed to the slope surface by 2 m long hardwood stakes driven through the gabions into the ground at 2 m interval. Galvanized-wire tension rods shall be provided to reduce distortion of the cages.
- iv) After several gabions have been placed in position adjacent to one another they shall be securely tied together continuously at their corners over their full height, and filled by hand with cobbles and rock fragments, as specified. Once full, the cage lid shall be placed in position and securely tied around its whole perimeter.
- v) Further gabions to be added, either above or adjacent to those already placed, shall be securely and continuously tied to existing gabions along all edges of contact before filling.

5.7 MASONRY WALLS

5.7.1 MATERIALS

- i) The Contractor shall construct wet masonry walls (or random rubble masonry), 30 cm thick minimum, for slope protection to the lines and in locations shown on the Construction Drawings or as directed by the Project Manager.
- ii) The stone for masonry walls shall be natural or crushed stone having sufficient strength and durability required for its use, not less than 150 mm thick. The rock shall be of suitable colour and appearance as determined by the Project Manager. The rocks in the exposed face shall be approximately flat.
- iii) Mortar for masonry walls shall comprise 3 parts of clean fine aggregate to one part of cement by volume. Fine aggregate and cement shall comply with the requirements specified in the Chapter "Concrete".

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5.7.2 EXECUTION


- i) Stones shall be moistened and hand-placed with un-coursed close joints onto a bedding of 200 mm thick drainage and 150 mm thick filter layers. Spaces between stones shall be filled with mortar. Surface joints shall be finished.
- ii) Weep holes of 50 mm diameter PVC pipe shall be installed through the wall to the pattern shown on the Construction Drawings or as directed by the Project Manager. The top surface of the wall shall be finished smooth with a trowelled layer of 100 mm capping concrete, having a 100 x 100 x 3 mm wire mesh placed in the fresh concrete some 25 mm from the top.
- iii) After completion of a section of masonry walls, it shall be cured with water and wet material such as jute bags, wet burlap, or similar for a minimum of 72 hours.

5.8 ANCHOR BOLT, WIRE MESH AND SHOTCRETE SLOPE PROTECTION

5.8.1 MATERIALS

- i) The Contractor shall use anchor bolt and shotcrete for slope protection to the lines and in locations shown on the Construction Drawings or as directed by the Project Manager.
- ii) There are three types of anchor bolt with shotcrete slope protection. Type A consists of a minimum shotcrete thickness of 5 cm, 25 mm anchor bolts of 2 m length spaced at 2.5 x 2.5 m on centres, chain link fence fabric Ø 3 mm x 50 mm x 50 mm and 50 mm weepholes spaced at 4 x 4 m on centres. Type B consists of a minimum shotcrete thickness of 10 cm, 25 mm anchor bolts of 3 m length spaced at 2 x 2 m on centres, welded steel wire fabric Ø 5 mm x 100 mm x 100 mm and 50 mm weepholes spaced at 4 x 4 m on centres. Type C consists of a minimum shotcrete thickness of 10 cm, 25 mm anchor bolts of 4 m length spaced at 2 x 2 m on centres, welded steel wire

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fabric Ø 5 mm x 100 mm x 100 mm and 50 mm weepholes spaced at 4 x 4 m on centres. The length of the weep holes for each type is 2.0 m.

- iii) The anchor bolts shall comprise of grouted anchor bars or, if requested by the Project Manager, of rock bolts and shall comply with the Chapter entitled "Rock Support". Shotcrete shall comply with the Chapter entitled "Shotcrete". In addition to the requirements of these two Chapters the Contractor shall qualify the method of using shotcrete for slope protection by making a trial test on an area of 4 m x 4 m with approximately 45° slope, with 4 rock bolts, and taking 8 core samples after 7 days to check the bond between the shotcrete and the sub-base and the integrity of the shotcrete layer. The 4 rock bolts shall be subject to a pull-out test of 150 kN. If a rock bolt is not able to resist a load of 100 kN it is considered to have failed.

5.8.2 EXECUTION


- i) The execution procedures shall follow the requirements of the Part II, Chapter "Shotcrete" and Chapter "Rock Support ", however the Contractor shall have pull-out tests on 1 per 25 rock bolts installed if cement-mortar grout is used, instead of 1 per 50 rock bolts otherwise. Rock anchor bolts with cement-mortar grout shall not be subject to any torque, only to the pullout tests.
- ii) Prior to placing shotcrete on rock, the surface shall be free of loose material and moist.

5.9 POLYETHYLENE SHEETS

5.9.1 MATERIALS

- i) Polyethylene (PE) sheet covers shall be considered only as a temporary protection measure. It can be used to cover small topsoil stockpiles, protect ditch side slopes, and stream bank from rainfall erosion until the excavation is complete. PE sheet covers shall only be placed and/or removed as directed by the Project Manager.

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- ii) It can also be useful in emergency situations such as on a large slope to reduce the risk of instabilities. Therefore, the Contractor shall always have 500 m² of clear plastic polyethylene sheeting

5.9.2 EXECUTION


- i) Plastic slope cover should be installed and maintained as follows:
- a) PE-sheets shall be un-rolled down the slope, not across the slope,
 - b) PE-sheets shall overlap by at least 300 mm at seams,
 - c) On top of a slope to be protected the PE-sheets shall be placed into a small, 50 cm deep trench. The trench shall be backfilled with soil to keep the PE-sheets in place and to stop the water from flowing underneath the sheets,
 - d) Sand filled jute bags shall be used along the seams to hold the sheet in place,
 - e) PE-sheets shall regularly be inspected for rips, tears, and open seams and repaired immediately.

5.10 LANDSCAPING (NOT REQUIRED)

5.10.1 MATERIALS

- i) The Contractor shall furnish all plants, labour, materials, tools and equipment necessary for the performance of all landscaping as directed by the Project Manager.
- ii) Landscaping shall comprise grading the ground surface to required profiles and dressing all areas to be planted with a minimum 15 cm layer of topsoil. Landscaped areas shall be planted with ornamental shrubs, grass sods, or trees, and steeply sloping surfaces shall be planted with grass and bushes including the stone pitched border to provide protection against erosion.
- iii) Ornamental shrubs shall be flowering and aromatic and have been developed in a nursery for at least two years.

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- iv) Trees shall have well-developed root system, straight trunks, well branched with dense foliage, free from plant disease.
- v) Grass and bushes for erosion protection shall comprise of pasture forage ground covers.
- vi) Material for stone pitched border shall be as per clause 5.5.1.

5.10.2 EXECUTION

- i) Planting areas shall be finish graded and waste material such as debris shall be removed from the site. Finish grade of all planting areas shall be 50 mm below finish grades of adjacent pavements or walkways.
- ii) Plant materials shall be planted on the day of delivery. Plant pits shall be excavated circular with vertical sides and flat bottom. Tree pits shall be at least 60 cm greater in diameter than the spread of roots and 15 cm below depth of roots. Ornamental shrubs shall be planted in pits 60 cm deep below finished grade. Bedding soil shall consist of 3 parts topsoil and 1 part peat by volume with the uppermost layer treated with 0.15 kg/m² chemical fertilizer. Plants shall be watered immediately after planting operations have been completed.
- iii) Topsoil at areas to be sodded or grassed for erosion protection shall be treated with 0.15 kg/m² chemical fertilizer. Sod shall be cut and laid on site the same day and laying shall be across slopes. After sodding, the sodded area shall be cleaned and thoroughly moistened using sprinklers.
- iv) Grass and bushes for erosion protection shall consist of contour cropping of pasture forage ground covers in furrows or planting strips 1.0 m wide at a density of 42 plants / m².
- v) Stone pitched border shall be placed as Clause 5.5.2.

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5.11 MEASUREMENT AND PAYMENT

5.11.1 ROCK PAVING (Not required)

- i) Separate payment will be made for dry rock paving and for rock paving in mortar.
- ii) Measurement will be by the volume of rock paving, placed to the lines and thicknesses shown on the Construction Drawings or those determined by the Project Manager. The actual surface area will be determined by survey.
- iii) Payment will be made at the appropriate Unit Price per cubic meter entered in the Bill of Quantities, which shall include for the cost of furnishing, handling, transportation, and placing of paving materials including sand and gravel or mortar bedding.


5.11.2 GABIONS (Not required)

- i) Measurement and payment will be made on the basis of the placed volume of the gabions.
- ii) Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities which shall include all labour, equipment, materials, required for furnishing, manufacturing, handling, transportation, and placing of wire crates, rocks and boulders.

5.11.3 MASONRY WALLS (Not required)

- i) Measurement of the masonry walls will be of the volume of walls, placed to the lines and thickness shown on the Construction Drawings for those determined by the Project Manager. Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include for the cost of furnishing, handling, transportation, and placing of rocks, mortar, capping concrete and drainage and filter layers.
- ii) Foundation excavation, blinding concrete and weep holes will be measured separately and paid for at the appropriate Unit Prices provided in other Chapters of these Specifications.

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5.11.4 ANCHOR BOLT AND SHOTCRETE SLOPE PROTECTION

- i) Measurement and payment of rock bolts, drilling for anchor bolts, shotcrete and wire mesh will be made as defined in Chapters "Rock Support" and "Shotcrete".


5.11.5 POLYETHYLENE SHEETS (Not required)

- i) Supply and placement of PE sheets shall be measured at a Unit Price per unit metre .
- ii) The related costs shall be for PE sheets placed as directed by the Engineer-in Charge, and shall include the removal and repair of the PE sheet and storage thereof for further use.
- iii) Excluded in measurements and payments are the costs associated with PE sheets which are used by the Contractor without the explicit directive of the Engineer-in Charge, or are used for the Contractor's own purpose.

5.11.6 TOPSOIL AND SEEDING (TURFING) (Not required)

- i) Measurement of topsoil will be of the volume placed within the lines shown on the Construction Drawings or as established by the Project Manager. Payment will be made at the Unit Price per cubic meter entered in the Bill of Quantities, which shall include all cost of labour, loading, transportation, placing, compacting, and excavating of additional material if necessary.
- ii) Measurement for seeding will be of the surface area actually seeded. Payment will be made at the Unit Price per square meter entered in the Bill of Quantities, which shall include the cost of furnishing, sowing, and covering of the seed, furnishing and spreading of fertilizer, furnishing and placing of mulch, and watering of field.

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5.11.7 LANDSCAPING (Not required)


- i) Measurement of landscaping will be of the area so treated, as shown on the Construction Drawings or as directed by the Project Manager. Payment will be at the Unit Price per square meter entered in the Bill of Quantities.
- ii) Separate payment will be made for topsoil, turf (field sod), and bushing as erosion protection or for planting shrubs in landscaped areas.
- iii) Measurement will be made of the actual area so treated, and payment will be made at the appropriate Unit Price per square meter entered in the Bill of Quantities. The Unit Price for planting shrubs and trees shall include the stone pitched border.
- iv) Additional payment will be made for planting trees, or as directed by the Project Manager. Measurement will be of the number of trees planted, and payment will be made at the Unit Price entered in the Bill of Quantities.

5.11.8 EXCLUSIONS

No extra measurement or payment will be made for the following:

- a) Extra work caused by the Contractor's negligence in setting-out the structures and slopes,
- b) Rectification, removal and replacement of the materials which during the placement or afterwards have been frozen, contaminated with foreign matter, mixed with materials from other zones, or lost due to erosion,
- c) Extra work or material required to repair damages to the temporary or final surfaces caused by the erosion or travel of construction equipment,
- d) Stockpiling, re-handling, reloading, and transport of materials, which cannot be directly placed in the final locations after being excavated,
- e) Increase of quantities caused by settlement resulting from the consolidation or compaction during the construction,

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<div> <div>f)</div> <div>Damage and repair to the concrete structures caused by Contractor's operations.</div> </div> <div>End of Chapter</div>		
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