

**Geosynthetics**

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**701. GEOSYNTHETICS IN ROAD AND BRIDGE WORKS****701.1 Scope**

This specification covers the various applications of Geosynthetic materials in road and bridge works including supplying and laying as per special provisions.

“Geosynthetic is a general classification for all synthetic materials used in geotechnical engineering application. It includes geotextiles, geogrids, geonets, geomembranes and geocomposites.

- (i) **Geotextile** : Any permeable textile natural or Synthetic, used with foundation, soil, rock, earth, or any other geotechnical engineering related material. In the present chapter, it is related to synthetic material only.
- (ii) **Geogrid** : A deformed or non-deformed grid of polymeric material used primarily for reinforcement purposes with foundation, soil, rock, earth, or any other geotechnical engineering related material.
- (iii) **Geonets** : These are net made of polymeric material used for drainage of foundation, soil, rock, earth or any other geotechnical engineering related material.
- (iv) **Geomembrane** : An essentially impermeable membrane of polymeric material used with foundation, soil, rock, earth or any other geotechnical engineering related material, to control fluid migration.
- (v) **Geocomposite** : A manufactured material using geotextiles, geogrids, geonets and/or geomembrane in laminated or composite form.”

**701.2 Material Testing and Acceptance**

Unless otherwise stated, these Geosynthetic materials shall conform to the requirements as under :

**701.2.1. Geotextile** : Geotextile shall be made of polyethylene or polypropylene or polyester or similar fibres, either woven or nonwoven in variety, through machine made process of heatbonding or needle punching or weaving techniques. These fabrics are required to pass water through but retain the soil particles, which require specific cross-plane permeability or permittivity and apparant opening size or equivalent opening size or 095. The above two requirements alongwith the requirement of strength and durability denote general characteristics of geotextiles to be used.

The type of geotextile to be used in a particular application shall be decided on the basis of design.

**701.2.2. Geogrid** : Geogrid shall be made from integrally jointed, mono or bi-directionally orientated or stretched meshes made from polyethylene or polypropylene or polyester or similar polymer, with high

secant modulus, in square, rectangular, hexagonal or oval mesh form. Their junction strength shall be high with high creep resistance, and dimensional stability. Their open structure shall permit effective interlocking with soil, aggregates, rock etc., they shall be used as a tensile member or reinforcement. Characteristics strength of such Geogrids varies from 40 kN/m to 200 kN/m peak strength at a maximum elongation of 15 per cent in the direction of the length of the roll.

**701.2.3. Geonet :** Geonet shall be made from a single extruded unoriented process from polyethylene or polypropylene or similar polymer. It shall have square or rectangular net shape aperture when used for protective works like gabions and mattresses. While in polygonal aperture it shall be used as a separator. It shall not be used as soil reinforcement due to its high creep characteristics, neither as a slope reinforcement or soil retaining wall or asphaltic reinforcement. Geonets used in protective works for highway structures shall be atleast 650 gm/sq.m. in unit weight. It shall be black in colour, available in roll form in suitable width.

**701.2.4. Geomembrane :** Geomembrane shall be made from PVC or polyethelene sheets of atleast 0.8 mm thickness, duly protected from ultra-violet exposure with 2.5 per cent carbon black, in black colour, supplied in roll form with 3 m or above width. The joints of these sheets shall be heatbonded or seamed for effective permeation cut off, at site using standard equipment as part of the laying process. While fixing on to a slope, they shall not be punctured or stappled to impair their use.

**701.2.5. Geocomposite :** Geocomposites shall be made from combination of geonets, geogrids or geomembranes of above description using heat bonded, seamed stitched or wrap techniques. Their principal use shall be to regulate drainage in cross-plane or in-plane directions. Minimum unit weight of such material shall conform to the special provisions or as per Contract drawing.

**701.2.6. Testing and acceptance :** Geosynthetics shall be tested in accordance with tests prescribed by BIS. In absence of IS Codes, tests prescribed either by ASTM or British Standards or International Standards Organisation, shall be conducted.

### **701.3 Application Areas**

Some of the application areas for geotextiles and related materials and

their functions are given below in table 700-1.

Table 700-1. Applications and Functions of Geosynthetics

| S. No. | Application Area   | Geosynthetics Involved   | Functions for Performance |
|--------|--|--|---------------------------|
| 1.     | Embankments on soft soils  | GT, GG   | R, S                      |
| 2.     | Retaining walls  | GG, GT   | R                         |
| 3.     | Drainage and Filtration  | GT   | F, S                      |
| 4.     | Drainage-prefab, composite   | GC, GN   | D, F, S, B                |
| 5.     | Erosion Control rip rap  | GT   | F, S                      |
| 6.     | Sediment control-silt fence  | GT   | B, R, S                   |
| 7.     | Asphalt overlay  | GT, GC   | B, R, S                   |
|        | Note : GT = geotextile<br>GG = geogrid<br>GC = geocomposite<br>GN = geonet | S = separation<br>R = reinforcement<br>F = filtration<br>D = drainage<br>B = barrier |                           |

## 702. GEOTEXTILES IN SUB-SURFACE DRAINS

### 702.1. Scope

The work covers the use of geotextiles in subsurface drains, such as fin drains or narrow filter drains. The fin drain shall mean a planar geocomposite structure designed to perform the same function as a narrow filter drain. The work shall be carried out as per design drawings.

### 702.2. Materials

702.2.1. The geotextile fabric shall be a woven or non-woven 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.

702.2.2. The geosynthetic material of which the drain is made shall be treated with carbon black so that they are protected from the deleterious effects of short term exposure to ultraviolet light, and shall be resistant to degradation by acid, alkalis, common chemicals, bacteria, fungi and moulds occurring in soils and highway construction materials. In case of exposure to ultraviolet light, the Engineer may require evidence that the geosynthetic material still complies with the requirements of this Clause. Where necessary, the side intended for entry of water and direction of in-plane flow shall be identified.

### 702.2.3. The geotextile shall :

- (a) Sustain a load of not less than 10 kN/m at break and have a minimum failure strain

of 10 per cent when determined in accordance with BS:6906 (Part 1) or shall have a grab tensile strength more than 0.4 kN/m and grab elongation corresponding to this limit in accordance with ASTM D 4632.

- (b) The apparent opening size\*<sup>@</sup> shall satisfy the following:

| Test Method | Units | Requirements                           |          |        |
|-------------|-------|--|----------|--------|
|             |       | per cent in-situ soil passing 0.075 mm |          |        |
|             |       | <15                                    | 15 to 50 | > 50   |
| ASTM D 4751 | mm    | 0.43                                   | 0.25     | 0.22** |

\*These default filtration property values are based on the predominant particle size of in-situ soil. In addition to the default permittivity value, the Engineer may require geotextile permeability and/or performance testing based on engineering design for drainage systems in problematic soil environments.

@ Site specific geotextile design should be performed especially if one or more of the following problematic soil environments are encountered; unstable or highly erodible soils such as non-cohesive silts; gap graded soils; alternating sand/silt laminated soils; dispersive clays; and/or rock flour.

\*\*For cohesive soils with a plasticity index greater than 7, geotextile maximum average roll values for apparent opening size is 0.30 mm.

- (c) allow water to flow through it at right angles to its principal plane, in either direction at a rate of not less than 10 litres/m<sup>2</sup>/sec. under a constant head of water of 100 mm, determined in accordance with BS:6906 (Part 3) or ASTM D 4491 or as stated in the design drawing. The flow rate determined in the test shall be corrected to that applicable to a temperature of 15°C using published data on variation in viscosity of water with temperature.
- (d) have a minimum puncture resistance of 200 N when determined in accordance with BS:6906 (Part 4) or ASTM D 4833.
- (e) have a minimum tear resistance of 150 N when determined in accordance with ASTM Standard D 4533.

**702.2.4.** The composite drain shall have a flow rate through each face of the drain of more than 75 per cent of the value specified in sub-Clause 702.2.3 (c), determined by direct measurement of the composite drain using BS:6906 (Part 3). The composite drain shall have values of long-term in-plane flow rates as stated in the design drawing.

**702.3. Installation**

**702.3.1.** The installation of fin drains shall be as per the design drawings. Where fin drains are assembled on site, the assembly area shall be clean and dry and free of any wind-borne pollutants. No geotextile or core material shall be exposed to daylight (or any source of ultraviolet radiation) for a period exceeding a cumulative total of 50 hours. Where

fin drains are laid in 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 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 jointed longitudinally or laterally into pipe systems or chambers for inflow and outflow purposes. Joints parallel to the direction of flow and any exposed edges shall be protected from the ingress of soil by a geotextile wrapping with a minimum overlap of 150 mm or other measures as agreed by the Engineer.

**702.4.** Narrow filter drains consisting of a porous or perforated pipe laid in a narrow trench surrounded by a layer of geotextile filter shall have the same properties of geotextile as specified in Clause 702.2. The spicing of lengths of geotextile and minimum overlap shall be as per the design drawing or as approved by the Engineer. Such drains shall be installed as per the design drawing to Clauses 702.3 and 309.3.5.

#### **702.5. Measurements for Payment**

Measurement for fin drain/narrow filter drains shall be per running metre length of the drain. Disposal of surplus material beyond 1000 m shall be measured in cu.m.

#### **702.6. Rates**

The Contract unit rates for subsurface drains shall be payment in full for all items such as excavation, dressing the sides and bottom, providing geotextile composites, laying and jointing pipes etc. including full compensation for all materials, labour, tools, equipment incidental to complete the work as shown on drawings with all leads and lifts except for removal of unsuitable material for which the lead shall be 1000 m. Provision of inlets, outlet pipes, bedding, etc., wherever required shall be incidental to construction of drain. The Contract unit for disposal of surplus and unsuitable material beyond the initial 1000 m lead shall be in accordance with Clause 301.3.11.

### **703. GEOSYNTHETICS FOR HIGHWAY PAVEMENTS**

#### **703.1. Scope**

This work shall consist of laying geosynthetic materials over existing bituminous surface, including preparation of surface and joining.

stitching or overlapping of geosynthetic fabric etc., as part of highway pavement strengthening in layers as shown on drawings.

### 703.2. Paving Fabrics

**703.2.1. Description :** This work shall consist of furnishing and placing as asphalt/bitumen overlay textile (paving fabric) beneath a pavement overlay or between pavement layers to provide a water resistant membrane and crack retarding layer.

### 703.3. Material Requirements

**703.3.1. Paving fabric :** The paving fabric will be a nonwoven heat set material consisting of at least 85 per cent by weight polyolefins, polyesters or polyamides. The paving fabric shall be resistant to chemical attack, rot and mildew and shall have no tears or defects which will adversely alter its physical properties. The fabric shall be specifically designed for pavement applications and be heat bonded only on one side to reduce bleed-through of tack coat during installation. The fabric shall meet the physical requirements of Table 704-2. Heavy duty paving fabrics should be used in areas experiencing unusually high impact forces or heavy loads such as airport runways and taxiways :

Table 704.2. Physical Requirements-Paving Fabrics

| Property          | Units       | Standard Requirements        | Test Method       |
|-------------------|-------------|------------------------------|-------------------|
| Tensile Strength  | Kg          | 36.3                         | ASTM D 4632       |
| Elongation        | %           | 50                           | ASTM D 4632       |
| Asphalt Retention | Kg/10 sq.m. | 10                           | Texas DOT 3099    |
| Melting Point     | °C          | 150                          | ASTM D 276        |
| Surface Texture   | -           | Heat bonded on one side only | Visual Inspection |

**Notes :**

1. Certification of conformance from paving fabric manufacturer may be required.
2. All numerical values represent minimum average roll values (average of test results from any sampled roll in a lot shall meet or exceed the minimum values) in weaker principal direction. Lot shall be sampled according to ASTM D 4354, "Practice for Sampling of Geosynthetics for Testing".
3. Conformance of paving fabrics to specification property requirements shall be determined as per ASTM D 4579, "Practice for Determining the Specification Conformance of Geosynthetics".

**703.3.2. Tack coat :** The tack coat used to impregnate the fabric and bond the fabric to the pavement shall be a paving grade Bitumen of 80-100 penetration. A cationic or anionic emulsion may be used as approved by the Engineer. The use of cutbacks or emulsions which contain solvents shall not be used.

#### **703.4. Construction and Installation Requirements**

**703.4.1. Shipment and storage :** The paving fabric shall be kept dry and wrapped such that it is protected from the elements during shipping and storage. At no time shall the paving fabric be exposed to ultraviolet light for a period exceeding fourteen days. Paving fabric rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The paving fabric shall be labeled as per ASTM D 4873, "Guide for identification, storage, and handling of geotextiles".

**703.4.2. Weather limitations :** Minimum air and pavement temperature shall be at least 10°C and rising for placement of bitumen and shall be at least 15°C and rising for placement bitumen emulsion. Neither bitumen tack coat nor paving fabric shall be placed when weather conditions, in the opinion of the Engineer, are not suitable.

**703.4.3. Surface preparation :** The pavement surface shall be thoroughly cleaned of all dirt, water, and oil to the satisfaction of the Engineer. Cracks 3 mm wide or greater shall be cleaned and filled with suitable bituminous material or by a method approved by the Engineer. Crack filling material shall be allowed to cure prior to paving fabric placement. Potholes and other pavement distress shall be repaired. Repairs shall be performed as directed by the Engineer.

**703.4.4. Tack coat application :** The tack coat shall be spread by means of a calibrated distributor spray bar. Hand spraying and brush application may be used in locations of fabric overlap. Every effort shall be made to keep hand spraying to a minimum. The tack coat shall be applied, uniformly to the prepared dry pavement surface at the rate of 1 kg/sq.m. or as recommended by the paving fabric manufacturer and approved by the Engineer. When using emulsions, the application rate must be increased as directed by the Engineer to offset the water content of the emulsion. Within street intersections, on steep grades, or in other zones where vehicle speed changes are common place, the normal



application rate shall be reduced by about 20 per cent as directed by the Engineer. The tack coat application rate must be sufficient to saturate the fabric and to bond the fabric to the existing pavement surface.

The temperature of the tack coat shall be sufficiently high to permit a uniform spray pattern. For bitumen, the minimum temperature shall be 140°C. To avoid damage to the fabric, distributor tank temperatures shall not exceed 160°C. For bitumen emulsions, the distributor tank temperatures shall be maintained between 55°C and 70°C.

The target width of tack coat application shall be equal to the paving fabric width plus 150 mm. The tack coat shall be applied only as far in advance of paving fabric installation as is appropriate to ensure a tacky surface at the time of paving fabric placement. Traffic shall not be allowed on the tack coat. Excess tack coat shall be cleaned from the pavement.

**703.4.5. Paving fabric placement :** The paving fabric shall be placed onto the tack coat using mechanical or manual laydown equipment capable of providing a smooth installation with a minimum amount of wrinkling or folding. The paving fabric shall be placed prior to the tack coat cooling and losing tackiness. Paving fabric shall not be installed in areas where the overlay asphalt tapers to a thickness of less than 40 mm. Excess paving fabric which extends beyond the edge of existing pavement or areas of tack coat application shall be trimmed and removed. When bitumen emulsions are used, the emulsion shall be allowed to cure properly such that essentially no water moisture remains prior to placing the paving fabric. Wrinkles or folds in excess of 25 mm shall be slit and laid flat. All transverse joints and slit folds or wrinkles shall be shingle-lapped in the direction of the paving operation. Brooming and/or pneumatic rolling will be required to maximize paving fabric contact with the pavement surface. Additional hand-placed tack coat may be required at laps and repairs as determined by the Engineer to satisfy bitumen retention of the lapped paving fabric. All areas with paving fabrics placed will be paved the same day. No traffic except necessary construction equipment will be allowed to drive on the paving fabric.

Turning of the paver and other vehicles shall be done gradually and kept to a minimum to avoid movement and damage to the paving fabric. Abrupt starts and stops shall also be avoided. Damaged fabric shall be removed and replaced with the same type of fabric. Overlaps shall be

shingle-lapped in the direction of paving. Additional tack coat shall be placed between the overlap to satisfy saturation requirements of the fabric. Overlap shall be sufficient to ensure full closure of the joint but not exceed 150 m.

**703.4.6. Overlay placement :** Bituminous overlay construction shall closely follow fabric placement. All areas in which paving fabric has been placed will be paved during the same day. Excess tack coat which bleeds through the paving fabric shall be removed. Excess tack coat can be removed by broadcasting hot mix or sand on the paving fabric.

## **704. PROTECTION WORKS WITH GEOSYNTHETICS**

### **704.1. Scope**

This work shall consist of laying boulder Gabions/Mattresses in wraps of Geosynthetics in the form of bolsters, on slopes of embankments or in apron. Gabions or Mattresses are also used for stone spurs. Geotextiles are used for prevention of migration of fine soil particles.

### **704.2. Gabions/Mattresses with Geogrids and Geonets**

Mattresses constructed with Geogrids or Geonets shall be used for thickness of 300 mm or above as shown in the drawings. While adopting a particular size for gabions or mattresses width of the roll of geogrid/geonet may be kept in view to minimise wastage of the geosynthetic in cutting off pieces. The mesh opening may vary depending on functional requirement but shall have aperture between 35 mm and 100 mm. The mesh/net shall have following characteristics :

|                       |   |   |
|-----------------------|---|---|
| Aperture              | : | Rectangular, square or oval shaped (and not in diamond, round or polygonal shape).  |
| Colour                | : | Black   |
| Mechanical Properties | : | Peak strength not less than 10 kN/m at maximum elongation of 15 per cent. Not more than 5 per cent elongation at half peak load.  |
| Stands/Fabric Form    | : | Integral joints with junction strength of 100 per cent of plain strands as measured by GRI-GG3 standards. Material shall have ISO 9002 certification.   |
| Life                  | : | Atleast 8 years in case of continuous exposure and 5 years for buried applications (defined as capable of retaining atleast 75 per cent of its original strength after the life span stated). |

### **704.3. Construction**

**704.3.1. Assembly :** Gabion and mattress boxes shall be assembled in situ, on a level surface. After fabrication is done in situ they shall be correctly filled in layers in dense packed state.

The bottom, sides and end panels shall be erected after removal of all kinks, kept in an upright position to form rectangular boxes by joining the sides with connectors of 40 mm x 6 mm size, or by ring staples. The top corners shall be tie tensioned from sides to keep it erect for filling. For gabions of 600 mm or more height, suitable cross internal ties shall be placed in layers of 300 mm connecting opposite sides in lateral braces tied with polymer braids of ultra-violet stabilised variety so as to ensure protection against bulging of the gabions during filling with stones.

**704.3.2. Construction and installation :** The filling of the gabion/mattress shall be done by hand in layers so as to minimise voids and achieve specified density. The stones in contact with the surface of the geogrids/geonets shall be placed in such a way that their sharp edges are kept turned inside so that they do not damage the material of the geogrids/geonets. The opposite panels of the boxes shall be firmly secured with lateral ties to withstand the design forces. The bottom of the gabion mesh shall be secured in a key type excavation for preventing slide. The space between the gabion and earthen sides shall be filled with sand and the filling compacted. In most of the cases design shall be supplemented with a layer of geotextile under the gabion/mattress to prevent migration of fines.

**704.3.3. Laying boulder apron in crates :** Mattresses of minimum height 300 mm shall be used. The typical size of a single continuous unit shall be 1 m x 5 m size with baffles at 1 m centres. The size of boulders shall be at least 100 mm or double the size of the aperture whichever is larger. The density of boulder filling shall be as stated in the drawing and the specific gravity of stones not less than 2.65. Methodology of laying boulders shall be as per Clause 2503.3. Gabions if placed in the apron shall be of size 1 m x 5 m in plan with height at least 600 mm, with baffles in 1 m centres.

Gabions or mattresses made with polymer geogrids/geonets shall always be laid in situ and shall not be performed, filled and transported to be dropped in deep waters. Where depth of water is low or dry bed is available, the boxes shall be filled in situ. In streams or water body having

running boulders in the bed, the gabions/mattresses shall be armoured with placement of loose large boulders alongside the gabion wall to protect against impact hit of stray boulders.

Stakes or keying shall always be provided in the founding recess, where the gabion be located, especially in case the ground is assessed to be sloping or yielding type.

**704.3.4. Groynes or spurs with crates :** Groynes or spurs of gravity retaining variety shall be constructed using geogrid/geonet gabions placed in stable configuration one over the other to form a well. They shall be filled in situ on a shallow depth of water or dry bed with firm founding and level strata. The provision of a layer of geotextile/geocomposite shall be made while placing the structure if resting over a bed of fine soil to prevent passage of fines and sinking.

**704.3.5. Measurements for payment :** The fabric of geotextile/geocomposite shall be measured in sq. metres of plan area of actual use (as per drawing).

The connecting rods or polymer braids shall be measured in metres. Ring staples shall be measured in number provided per linear metre.

The boulder fill shall be measured in cubic metres.

The excavation for keying of gabions in the ground trenches shall be measured in cubic metres.

The backfilling in side trenches shall be deemed part of the excavation work.

**704.3.6. Rate :** The cost of Geosynthetic material for fabrication of Gabions/Mattresses shall be all inclusive of supply, transportation and storage.

The contract rate per cubic metre of crate fill shall consist of cost of boulders and their transportation.

The contract rate for excavation and backfilling of trenches, seating trench upto 15 cm (included in rate), shall include cost of labour, tools and plant for completion of the work.

The cost of making a crate shall include preparation of box of geogrid/geonet, tensioning and staking arrangements, tying, internal crossbraids, etc., for forming of the crates in an engineered manner and filling the

crate by laying boulders. The cost shall include transportation of material from store to site.

Wherever composite system using Geosynthetics with natural material like stone revetment etc. shall be used, the provision of measurement and rate as per Clauses 2509 and 2510 are applicable.

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