Technical Note No:9

Sub: APRRP-BT/CC Pavements – Geosynthetics- Design, Construction and Testing of Geotextiles -Specifications to be followed- Reg.

Ref: Package No:20 Of Guntur Dist. (Tenali Division).

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1. Introduction: To overcome the immature failure of Pavements in poor subgrade soils where the CBR is ranging from 1 to 3 percent, Geotextile provision was made in certain packages of APRR Project as against to the conventional provisions to enhance the life of the Pavement.

Different Types of Geosynthetics used in Road construction:

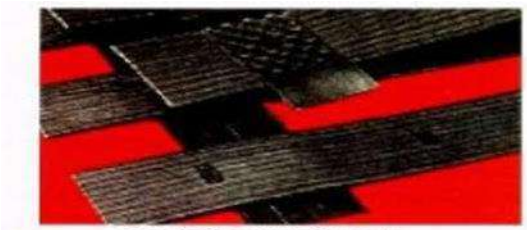


Fig. 5 : Bonded Geogrid

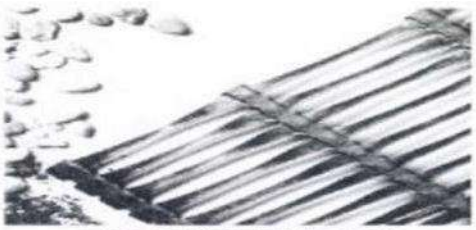
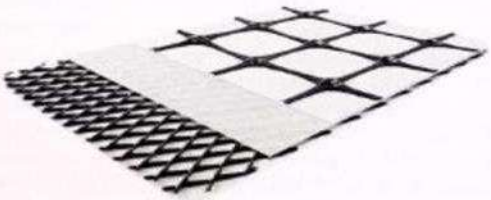


Fig. 6 : Extruded Geogrid

Fig. 7 : Woven Geogrid

Fig. 8 : Woven Geotextile



9/4/2020 Fig. 9 : Geocomposite

Fig. 10 : Knitted Geogrids 150

Type of Geosynthetic proposed in APRRP: Polypropylene Woven Geotextile

2. Functions of Geosynthetics:

1. Filtration
2. Separation
3. Drainage
4. Stabilization/Reinforcement

Selection of Type of Geosynthetics:

Type of Geosynthetic (GS)	Separation	Reinforcement	Filtration	Drainage	Containment	Protection	Erosion Control
Geotextile	■	■	■	■		■	
Geogrid		■					
Geonet				■			
Geomembrane					■		
GCL					■		
Geofoam	■	■					
Geocells	■	■					
Geocomposite	■	■	■	■	■		
Polymer Gabion						■	■
Geobags						■	■
Geotextile Tubes				■		■	■
PVDs			■	■			
Geomats		■		■			■
Geopipes				■			
Geonets				■		■	■
Natural Fibre Geosynthetics	■	■	■	■			
Mostly used →	■						

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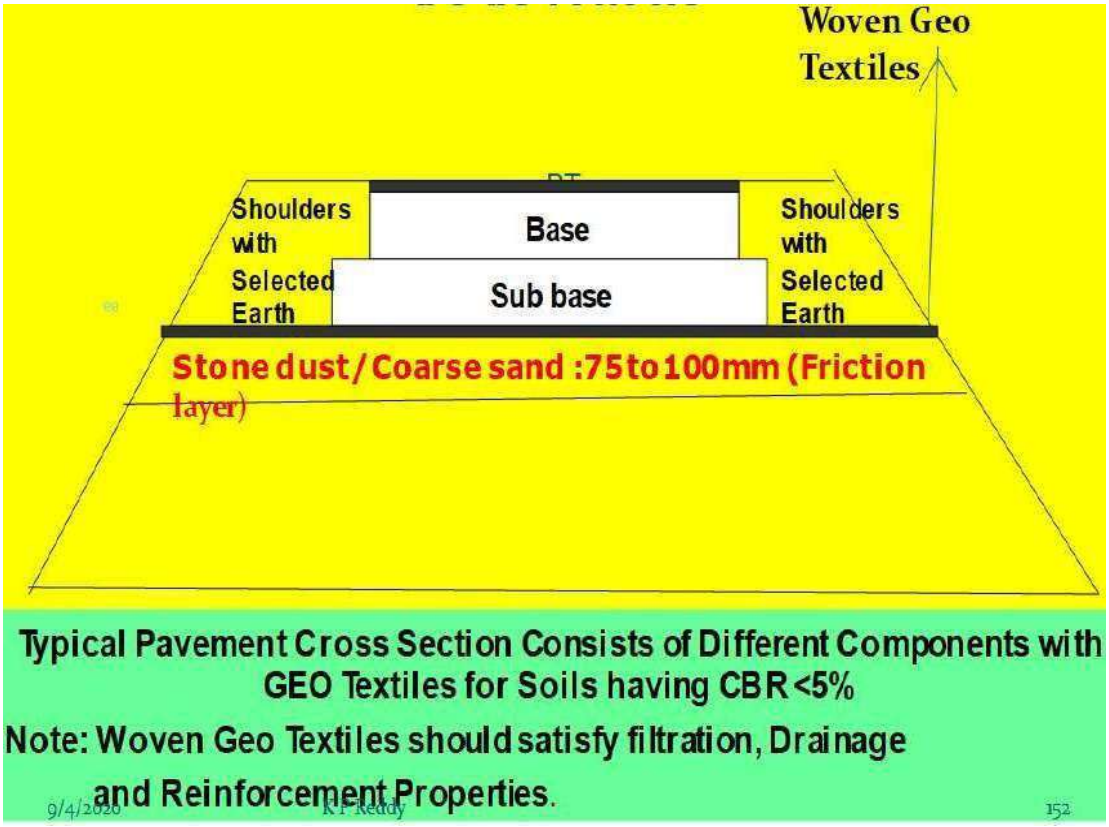
Table 1: Summary of Functionality and Product Matrix

3. Design for Reinforcement of Unbound Pavement Layers:

Pavement reinforcement involves reinforcing different layers of the pavement. Geosynthetics are incorporated into base and subbase section for following reasons:

1. To provide subgrade restraint for construction of the road over the weak subgrade conditions.
2. To reinforce the base and /or sub base.

Typical cross section adopted in APRR Project is as follows



3.1 Basic Mechanism

Basic mechanism of reinforcement can be identified as (a) Lateral restraint, (b) Improved bearing capacity, and (c) tensioned membrane effect.

- Lateral restraint **(Fig. 3.1(a))** refers to the confinement of the aggregate material during loading.
- Improved bearing capacity is achieved by shifting the failure envelope of the pavement system from the relatively weak subgrade to the relatively strong base course material **(Fig. 3.1(b)).**
- The third fundamental reinforcement mechanism has been termed the "tensioned membrane effect". The tensioned membrane effect **(Fig. 31(c))** is based upon the concept of an improved vertical stress distribution resulting from tensile stress in a deformed membrane.

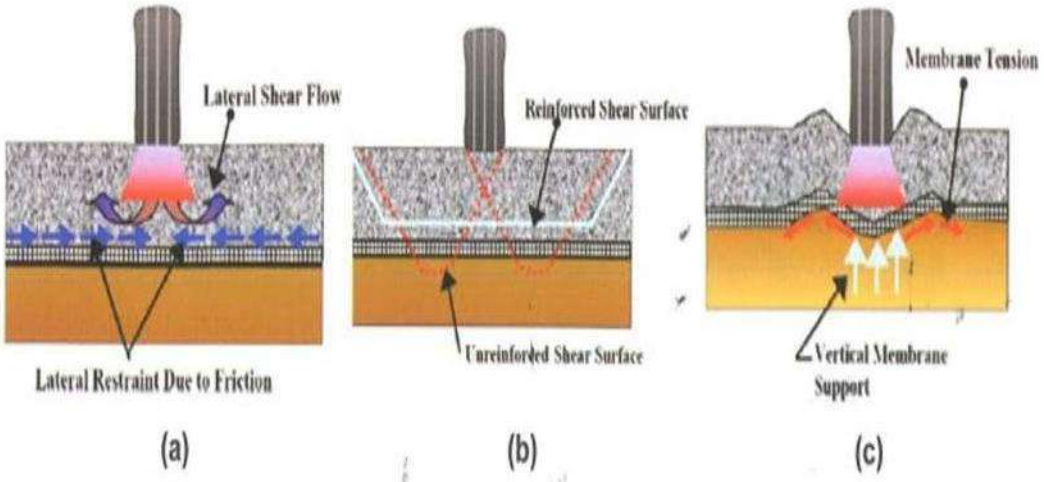


Fig. 3.1 Mechanism of Reinforcement: (a) Lateral Restrain Effect, (b) Improved Bearing Capacity, (c) Tension Membrane Effect

3.2 Designing for Separation:

Separation is the major function of Geotextile. The Geotextile has to be placed on the soil subgrade and then have aggregate Base/Subbase course spread over the Geotextile and compacted on top of it **(as shown in Fig.3.3).**

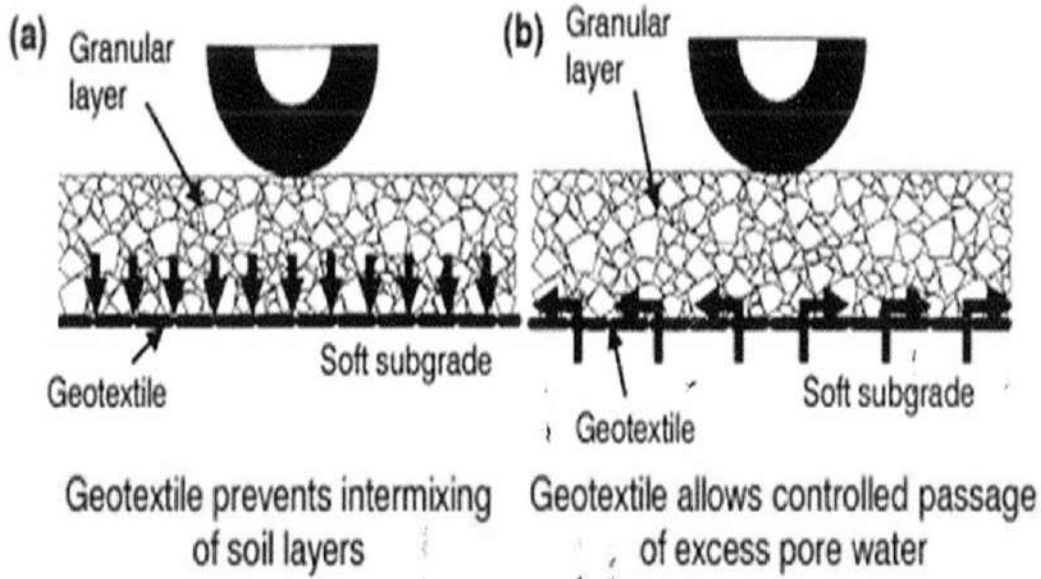


Fig. 3.3 Separation Function of Geotextile

3.3 Subgrade Stabilization:

A geotextile primary stabilization mechanism is filtration and separation of a soft subgrade and the subgrade and the subbase or base material. Secondary mechanism of a geotextile are lateral restraint and reinforcement. Lateral restraint is achieved through friction between the surface of the geotextile and the subbase or base materials. Stabilization function of geotextile is applicable to pavement structures constructed over the soils with a CBR between 1 and 3.

4. Property Requirements

4.1 Specific Gravity

The specific gravity of fibers from which geotextiles are made is actually the specific gravity of the polymer raw material. Some typical values of specific gravity of commonly used polymeric materials made into geotextiles are as follows.

Polypropylene	:	0.91
Polyester	:	1.22 to 1.38
Nylon	:	1.05 to 1.14
Polyethylene	:	0.90 to 0.96
Polyvinyl chloride	:	1.69

4.2 Mass per Unit Area:

Mass per unit area governs the fabric cost and normally mechanical properties are directly related to it. The geotextiles mass per unit area is given in grams per square meter. The range of typical values for most geotextiles is from **100 to 1000 gm/Sq.m**

4.3 Thickness

Thickness is measured as the distance between the upper and the lower surface of the fabric, measured at a specified pressure. The thickness is to be measured to an accuracy of at least 0.01 mm under a pressure of 2 kPa. The thickness of the commonly used geotextiles ranges from **0.25 to 7.5 mm.**

4.4 Ultraviolet Stability

4.4.1 Ultraviolet light degradation is a process where a particular property of a geosynthetic is damaged or reduced through its exposure to U-V Rays (Sunlight).

The rate of deterioration varies with the product, the exposure environment and the time of exposure. Atmospheric exposure of geosynthetic material following laydown shall be a maximum of 14 days to minimize the damage potential. **Table 4.1** gives specifications for ultraviolet light degradation.

Table: 4.1 Requirements for Ultra Violet Stability

S. No	Properties of Fabric		Requirements (Retained Strength)
1	Grab Strength	UV Stability as per IS 13162 Part 2/ASTM D 4355	Not less than 70% after 500 hours of exposure
2	Tear Strength		
3	Puncture Strength		
4	Burst Strength		

4.2 Separation/ Filtration Requirements

In roads and pavements works geotextile is the most preferred geosynthetic material which satisfies the function of separation /filtration which prevents intermixing of subgrade soil and aggregate cover material (Base/Subbase) with sufficient filtration. **Table 4.2 and 4.3** explain the geotextile property requirements for separation function.

Table 4.2 Geotextile Requirements for Separation (Subgrades Soaked CBR >3)

Sl. No.	Geotextile Property	Requirement
1.	Permittivity as per IS 14324/ASTM D 4491	0.02 sec^{-1} (per sec)
2.	Maximum Apparent Opening Size as per IS 14294/ ASTM D 4751	0.60 mm

Table 4.3 Geotextile Requirements for Separation (Subgrades Soaked CBR ≤3)

Sl. No.	Geotextile Property	Requirement
1.	Permittivity as per IS 14324/ASTM D 4491	0.05 sec^{-1} (per sec)
2.	Maximum Apparent Opening Size as per IS 14294/ ASTM D 4751	0.43 mm

4.3 Base/Subbase Reinforcement Requirements

Geosynthetics have been found to be a cost-effective alternative to improve poor sub-soils in adverse locations.

4.3.1 Geotextile requirements: The geotextile can also provide the function of reinforcement along with separation and filtration. The geotextile shall meet the strength property requirements as specified in table 4.4a and 4.4b.

Table 4.4a Minimum Geotextile Strength Property Requirements

Installation condition	Type	Strength Property Requirement (MARV)					
		Grab Strength in Newton (N) as per IS 16342/ASTM D 4632		Tear Strength in Newton (N) as per IS 14293/ASTM D 4533		Puncture Strength in Newton (N) as per IS 16078/ISO 12236/ ASTM D 6241	
		Elongation at Failure					
		<50%	≥50%	<50%	≥50%	<50%	≥50%
Harsh installation condition	Type I	1400	900	500	350	2800	2000
Moderate Installation condition	Type II	1100	700	400	250	2250	1400
Less Severe Installation condition	Type III	800	500	300	180	1700	1000

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 geotextiles are joined together by field sewing, the seam strength shall be at least 60 per cent of the material's tensile strength. All field seams shall be sewn with thread as strong as the material in the fabric.

(3) **Table 4.4b** provides required degree of survivability as a function of ground conditions, construction equipment, and lift thickness of Type 1, 2 and 3 as given in **Table 4.4a**.

Table 4.4b Required Degree of Survivability

	Low Ground Pressure Equipment ≤25 kPa (3.6 psi)	Medium Ground Pressure Equipment >25 to ≤50 kPa (>3.6 to ≤7.3 psi)	High Ground Pressure Equipment >50 kPa (>7.3 psi)
Subsoil has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris, surface is smooth, and level so than any shallow depressions and humps do not exceed 450 mm (18 in.) in depth or height. All larger depressions are filled, Alternatively, a smooth working table may be placed.	Low (Type 3)	Moderate (Type 2)	High (Type 1)

	Low Ground Pressure Equipment ≤25 kPa (3.6 psi)	Medium Ground Pressure Equipment >25 to ≤50 kPa (>3.6 to ≤7.3 psi)	High Ground Pressure Equipment >50 kPa (>7.3 psi)
Subsoil has been cleared of obstacles larger than small to moderate sized tree limbs and rock. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 450 mm (18 in.) in depth or height. Larger depressions should be filled.	Moderate (Type 2)	High (Type 1)	Very high (Type 1+)
Minimal size preparation is required. Trees may be felled, delimbed, and left in place, stumps should he cut to project not more than ±150 mm (±6 in.) above subgrade. Geotextile may be draped directly over the tree trunks, stumps, large depressions and humps, holes, stream channels, and large boulders, items should be removed only if placing the geotextile and cover material over them will distort the finished road surface.	High (Type 1)	Very high (Type 1+)	Not recommended

Recommendations are for 150 to 300 mm (6 to 12 in.) initial lift thickness.

For initial lift thicknesses:

300 to 450 mm (12 to 18 in.): reduce survivability requirement one level;

450 to 600 mm (18 to 24 in.): reduce survivability requirement two level;

>600 mm (24 in.): reduce survivability requirement three level;

For special construction techniques such as prerutting, increase the geotextile survivability requirement one level. Placement of excessive initial cover material thickness may cause bearing failure of the soft subgrade.

5. Construction Guidelines

These construction guidelines are related to placing of geosynthetic material between base or sub base and subgrade for any of the following applications.

- Base or subbase separation
- Base or Subbase Stabilization
- Base or subbase capillary barrier
- Base or Subbase Reinforcement.

5.1 The site should be cleared grubbed and excavated to design grade, stripping all top soil, or any other unsuitable material. Provide coarse sand/ stone dust as a levelling course over the compacted subgrade to have uniform level to cushion the Geosynthetic.

5.2 Once the subgrade along a particular segment of the road alignment has been prepared, the geosynthetic should be rolled in line with the placement of the aggregate. The entire roll should be placed and rolled out as smoothly as possible. Wrinkles and folds in the fabric should be removed by stretching and stacking as required. The geosynthetic should not be dragged across the subgrade.

5.3 Adjacent rolls of geosynthetic should be overlapped. For curves, the geosynthetic should be folded or cut and overlapped in the direction of construction. Folds in the geosynthetic should be stapled or pinned approximately 0.6 m Centre - to -Centre as shown in **Fig. 5.4(a) and (b).**

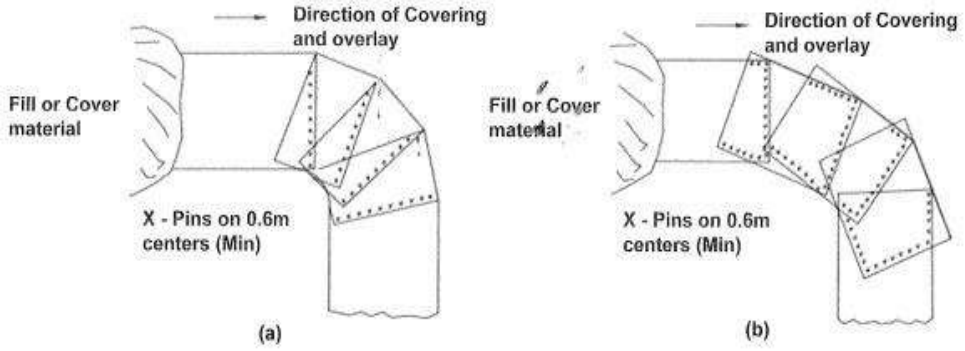
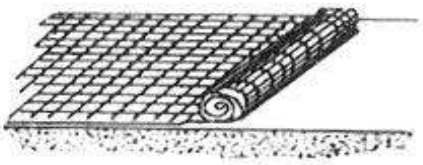


Fig. 5.4 Folding of Geosynthetics

5.4. The first lift of aggregate should be spread and graded to 300 mm, or to design thickness if less than 300mm prior to compaction. At no time should traffic be allowed on a soft roadway with less than 200 mm of aggregate over the geosynthetic.

5.5 All remaining base aggregate should be placed in lifts not exceeding 250mm in loose thickness and compacted to the specified density. Different operation sequences for construction are shown in Fig. 5.5.

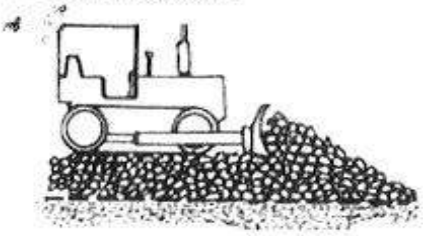
a. PREPARE THE GROUND BY REMOVING STUMPS, BOULDERS, ETC; FILL IN LOW SPORTS



b. UNROLL THE GEOTEXTILE DIRECTLY OVER THE GROUND TO BE STABILIZED. IF MORE THAN ONE ROLL IS REQUIRED, OVERLAP ROLLS. INSPECT GEOTEXTILES

Prepare the Ground

Unroll the Geotextile

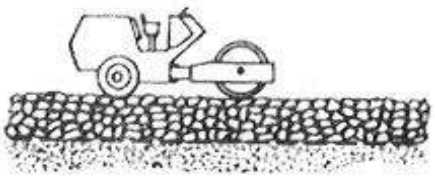


c. BACK DUMP AGGREGATE ON TO PREVIOUSLY PLACED AGGREGATE. DO NOT DRIVE ON THE GEOTEXTILE. MAINTAIN 150mm TO 300mm COVER BETWEEN TRUCK TYRES AND GEOTEXTILE

Back Dump Aggregate

d. SPREAD THE AGGREGATE OVER THE GEOTEXTILE TO THE DESIGN THICKNESS

Spread the Aggregate



e. COMPACT THE AGGREGATE USING DOZER TRUCK OR SMOOTH DRUM VIBRATORY ROLLER

Fig. 5.5 Construction Sequence

5.6 Geosynthetic Overlaps.

When geosynthetic material is used the overlaps can be used to provide continuity between adjacent geosynthetic rolls through frictional resistance between the overlaps.

Table 5.1 Overlap Requirement of Geotextile for Different CBR Values (IS 16345)

Soil Strength (CBR)	Overlap Unsewn, cm	Overlap Sewn, cm
Greater than 3 and above	60	-
2-3	76	8
1-2	97	20
Less than 1	-	23
All Roll Ends	100	25

6. Protection from sunlight (ultraviolet light) degradation

Geosynthetic material slowly degrade in the presence of ultraviolet light. The geosynthetic material should always be installed within the period required by the project specification. If no time requirements are specified, it is generally recommended that geosynthetic exposure to ultraviolet light be limited to a period of approximately **two weeks.**

7. Testing, Certification and Acceptance;

7.1 Geosynthetic Materials shall be tested and Certified in the following manner as per Clause 701.2 of MORT&H (5th Revision) and Chapter 2 of IRC: SP:59-2019 since MoRD 2014 is silent on this subject.

a) The manufacturer shall have ISO or CE certification for manufacturing process and quality control.

b) The manufacturer shall provide manufacturer's test certificate for every lot supplied from the factory.

c) 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.

7.2 The list of accreditation labs as per Annexure-2 of IRC:113-2013 is enclosed as **Annexure -1.**

7.3 One of the institutes, Geosynthetic Testing Services Pvt Ltd, Ahmedabad is having Accreditation with **both TRI and BTTG** as shown in **Annexure-2.**

Annexure - 1: Extract of IRC:113-2013.

Annexure 2
(Refer Clause 3.7)

CERTIFICATION FOR REDUCTION FACTORS OF GEOSYNTHETIC REINFORCING ELEMENTS

The following agencies provide certification for the use of geosynthetic material as reinforcing elements. These certifications are based on the results of the required tests carried out at accredited laboratories. Both the certifications are accepted in many countries of the world.

1) British Board of Agreement (BBA)

2) National Transport Product Evaluation Program (NTPEP)-AASTHO

Table -List of some Accredited Testing Laboratory for Geosynthetic Materials

S. No.	Name of Laboratory	Type	Remarks
1)	TRI/Environmental	Third party independent laboratory	
2)	SGI Testing Services, LLC	Third party independent laboratory	
3)	tBU	Institute	
4)	British Textile Technology Group (BTTG)	Third party independent laboratory	Tests on Durability are performed. Installation and creep tests are not done
5)	The Bombay Textile Research Association (BTRA)	Institute	Has testing facilities for some properties, but not for any of the reduction factors.

Table -List of Accreditation Institutes for Geosynthetic Testing Laboratories

Sr. No.	Name	Location	Email
1)	Geosynthetic Accreditation Institute (GAI) – Laboratory Accreditation Program (LAP)	United States of America (U.S.A.)	gkoerner@dca.net
2)	Deutsches Institut für Bautechnik (DIBt)	Germany	dibt@dibt.de
3)	United Kingdom Accreditation Service	United Kingdom	info@ukas.com

The certification of reduction values may also be based on test certificates issued by laboratories accredited by agencies listed in table above.

The list of some of the accredited laboratories is also available in http://www.geosynthetic-institute.org/gai/lab.htm

Annexure-2

GEOSYNTHETIC TESTING SERVICES

Company Profile

Geosynthetic Testing Services Pvt Ltd (i.e. GTSPL) is an independent, third party, geosynthetic firm providing specialised geosynthetics laboratory conformance/verification testing, engineering consulting, research and educational services. GTSPL is unaffiliated with any manufacturer, engineering firm or federal agency, and thus provides objective technical services to regulators, manufacturers, engineering firms, contractors and installers.

GTSPL is accredited for designated test methods in accordance with the **Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP)**, as published in its annual directory.

This is a joint venture company owned by BTTG Testing & Certification Ltd. and TRI Environmental Inc.

BTTG Testing & Certification Ltd. is based in Manchester, United Kingdom. With almost a century's experience in textiles and related products, BTTG™is the leading independent organisation for the testing & certification of Personal Protective Equipment (PPE), Geosynthetics, Floor coverings and other construction and performance textile products.

TRI Environmental Inc. is headquartered in Austin, Texas, USA and is an independent, third-party laboratory providing testing, research, education, certification testing, and equipment for the geosynthetic, geotechnical, plastic pipe, protective glove, and related technical textile industries.

For more information and assistance with enquiries, please get in touch with Mr.Ravi Kant, Acting Operations Head at rkant@gts-pl.com or Tell : +91 (02717) 250019 or Cell : +91-9023262679.

Websites:
www.GeosyntheticTesting.com
www.bttg.co.uk

TRI ENVIRONMENTAL

GEOSYNTHETIC TESTING SERVICES PVT. LTD.
Plot No 2, Ashwamegh Industrial Estate,
Nr Changoadar Bridge,Changodar,
Ahmedabad -382213
Phone: 02717-250019

BTTG

Photograph showing the process of laying PP Woven Geotextile and back dumping of GSB material is in progress.

Design Engineer.
PMC. APRRP
Vijayawada.

References: 1) IRC: SP:59-2019; Guidelines for use of Geosynthetics in Road Pavements and associated works (First Revision)

2) IRC:113- 2013: Guidelines for the Design and Construction of Geosynthetic Reinforced Embankments on Soft Subsoils.

3) MoRTH - 5th Revision (Section 700).