Testing of Geosynthetics

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Need for Testing

• Identification of product
• Selection of suitable materials as per the design specifications or regulations
• Quality control – during production stage
• Quality Assurance – during the construction stage
Collection of Test Samples

- ASTM D4354 “Standard Practice for Sampling of Geosynthetics for Testing”
- ISO 554 “Standard Atmospheres for conditioning and/or testing – specifications”
- ISO 9862 – “Geotextile – Sampling and Preparation of Test Specimen”
- IS 14706 – “Geotextile – Sampling and Preparation of Test Specimen”
- During production stage, test samples are collected at uniform intervals for quality control purposes.
- During the construction also, test samples are collected at specified intervals
- Number of specimens to be tested is given in respective standards.
Identification of the test samples

- Brand/producer/supplier
- Description of the type (grade, etc.)
- Roll number
- Date of sampling

The sample shall be kept in a dry, dark place protected against chemical and physical damage at ambient temperature.

Samples should be packed properly during shipping to the testing laboratories.
Types of Geosynthetic Products

- Geotextiles
- Geogrids
- Geonets
- Geomembranes
- Pre-fabricated vertical drains (PVD)
- Geosynthetic Clay Liner (GCL)
- Geocells (3-d confinement)
- Geobags/Geotubes
- Geocomposites & Geo-others
Geotextile Properties

- Physical Properties
- Mechanical Properties
- Hydraulic Properties
- Endurance Properties
- Degradation Properties
Geotextiles – Physical Properties

- Specific Gravity
- Mass per Unit Area
- Thickness
- Stiffness
Specific Gravity ASTM D792

- It is the ratio of the substance’s unit volume weight to that of distilled, de-aired water at 27°C temperature.
- Determined by Pycnometer method or density bottle method
- Sinkers used for testing materials that float in water

Typical values

<table>
<thead>
<tr>
<th>Material</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>7.87</td>
</tr>
<tr>
<td>Soil</td>
<td>2.7</td>
</tr>
<tr>
<td>Rock</td>
<td>2.4</td>
</tr>
<tr>
<td>PVC</td>
<td>1.69</td>
</tr>
<tr>
<td>Polyester</td>
<td>1.22 to 1.38</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.05 to 1.14</td>
</tr>
<tr>
<td>Poly ethylene</td>
<td>0.90 to 0.96</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>0.91</td>
</tr>
</tbody>
</table>
Mass per unit area (ASTM D5261)

• Cut five to ten specimens, each of an area not less than 10,000 mm\(^2\). Combined total area of not less than 100,000 mm\(^2\)

• Dimensions are measured without applying any tension

• Measure the mass of the samples accurate to 0.01 g

• Mass per unit area = total mass/total area

• Report in g/m\(^2\) to the nearest 0.1 g/m\(^2\)
Thickness (ASTM D5199)

• Distance between the upper and lower surfaces of a fabric at a pressure of 2 kPa
• Expressed in mm
• Woven geotextiles 0.25 to 1 mm
• Nonwoven geotextiles 1 mm to more than 10 mm
• Compressibility is change in thickness with pressure
Stiffness

• Stiffness is a measure of the interaction between the geotextile weight and its bending stiffness
• Slide a 25 mm wide strip of geotextile on an inclined plane at an angle of 41.5° and measure the length of the overhang (L) when the tip bends under its own weight
• Stiffness = \((L/2)^3 \times \text{mass per unit area (mg-cm)}\)

Subgrade CBR  |  Stiffness requirements (mg-cm)
---|---
< 0.5  |  15000 – 25000
1-2  |  5000 – 10000
> 2  |  ~1000
Mechanical Properties

- Compressibility
- Tensile Strength
- Seam Strength
- Fatigue Strength
- Burst Strength
- Tear Tests
- Impact Tests
- Puncture Tests
- Friction Behavior
- Pullout Tests
Compressibility

- Compressibility is the variation of the thickness of geotextile at different normal pressures
- Thickness of woven geotextiles is nearly constant at all normal pressures
- Thick nonwoven (especially needle punched) exhibit marked reduction in thickness at higher pressures
- Permeability properties are dependent on the normal pressures
Figure 2.5 Compressibility of different types of geotextiles, where NW-NP = nonwoven needle punched, and NW-HB = nonwoven heat bonded.

Koerner (1986)
Trapezoidal Tear Tests ASTM D4533

• One of the tests to ascertain construction survivability
• Initially a small cut is given in the sample and the force required to tear the sample is measured
• Force is applied on the sample in such a way that the initial tear is opened up.
• Result is reported in force units.
Trapezoidal Tear Test Sample (all dimensions in mm)

- Width of grips 76
- Rate of test: 300 mm/minute
- Initial gap between grips: 25

Grip along these edges
Wedge type grips used for trapezoidal tear test in progress
Grab Tensile Strength (ASTM D4632)

- Construction survivability test
- Especially for separator applications in pavements
- 25mm wide Narrow grips used to perform the test
- Test result is force in Newtons and rupture strain
- Loading at 300 mm per minute
Photos of Grab tension test
Tensile Strength Tests on Geotextiles (ASTM D 4595)

- Different Types of Tests
- Wide width tests 200 mm wide and 100 mm length
- Narrow strip tests – 50 mm wide strips used for tests
- Samples usually gripped in roller grips
- Load applied at 10-20% strain per minute
- Result is reported in units of force/unit width and the strain at peak load
Wide width tensile strength test on geotextiles
Testing of Geosynthetics-1
Force-strain behaviour of a typical nonwoven geotextile
Geotextile tubular structures undergo large strains due to deformations and ground movements. Force developed in fabric is very low as they are not filled completely. Forces depend on the fill ratio.

Application of geotextile bags and tubes for shore line protection.
Punching Strength ASTM D4833

- 8 mm diameter probe punched into a stretched geotextile
- Container diameter is 45 mm
- Peak load developed is reported in Newtons
CBR Puncture Test

- ASTM D6241 using the same device
- Probe is 50 mm diameter
- Container is 150 mm diameter
- 10 specimens across roll width
- Strength and deformation monitored
- Average value is reported
Tensile strength from CBR Test data

wide width tensile strength, \( T_f = \frac{F_p}{2\pi r} \)

\( T_f = \text{force in kN/m} \)
\( F_p = \text{punching force, kN} \)
\( r = \text{radius of CBR plunger} \)

Strain at failure, \( \varepsilon_f \)

\( \varepsilon_f = \frac{(x - a)}{a} \times 100 \)

\( x = \text{diagonal distance at failure} \)
\( a = \text{horizontal distance between outer edge of plunger and inner edge of mould} \)
Stone filled rope net gabions

Punching strength test on rope net gabions
Load-strain data from punching tests on rope nets
Dynamic Puncture Strength

- A 1 kg pointed cone of standard dimensions is dropped from a height of 1 m onto a stretched geotextile specimen.
- Diameter of the hole made by the cone is measured by a graduated cone.
- The larger the hole diameter, larger is the construction induced damage.
Seam Strength Tests

• Normal size of roll width is 3 to 5 m and length ~100m.
• Larger size areas covered by seaming geotextiles
• Preferably the thread for seaming should be same type as the geotextile – polyester, polypropylene, etc.
• Single stitch, double stitch, J-seam, Butterfly seam, etc.
• Seam strength is important as it may control the designs
• Tensile strength tests performed on the seams
• Procedure is same as that for normal tensile strength tests on virgin samples
• Efficiency = strength of seam/strength of virgin material
Burst Strength (ASTM D3786)

- Mullen burst strength – stone puncturing into a separation layer
- Inflatable rubber membrane used to distort the geotextile into a hemisphere of 30 mm diameter.
- When geotextile cannot deform any further, it will burst.
Fatigue strength

Tensile strength of coir geotextile after repeated loading
Summary

In this lecture, we have studied the testing for two types of the properties of geotextiles.

• Physical properties
• Mechanical properties