भारतीय मानक

Indian Standard

IS 16362 : 2024

(Amalgamating IS 15910 : 2010, IS 16391 : 2015, IS 16392 : 2015, IS 16393 : 2015)

भू-कृत्रिम — उपसतह जल निकासी, सबग्रेड अलगाव, सबग्रेड स्थिरीकरण, निस्पंदन और कटाव नियंत्रण (हार्ड कवच प्रणालीयों में) अनुप्रयोगों के लिए भू-वस्त्रादि — विशिष्टि

(दूसरा पुनरीक्षण)

Geosynthetics — Geotextiles for Subsurface Drainage, Subgrade Separation, Subgrade Stabilization, Filtration and Erosion Control (In Hard Armor Systems) Applications — Specification

(Second Revision)

ICS 59.080.70

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Geosynthetics Sectional Committee, TXD 30

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Textiles Division Council.

This standard was first published in 2015. The first revision of the standard was brought out in 2020 to modify the requirement of CBR puncture strength and exclude the requirements for burst strength, pullout interaction coefficient and coefficient of direct shear.

Following standards were published on geotextiles for different applications including subgrade separation, erosion control in hard armor systems, subsurface drainage and geotextiles for highways application, the Committee responsible for the formulation of these standards has decided to amalgamate these standards in a single standard:

a) IS 15910 : 2010 'Geosynthetics for highways — Specification';

b) IS 16391 : 2015 'Geosynthetics — Geotextiles used in sub-grade separation in pavement structures — Specification';

c) IS 16392 : 2015 'Geosynthetics — Geotextiles for permanent erosion control in hard armor systems — Specification'; and

d) IS 16393 : 2015 'Geosynthetics — Geotextiles used in subsurface drainage application — Specification'.

After the publication of this standard, the above standards shall be treated as withdrawn and relevant parts, varieties and their requirements have been covered in this standard. Additionally, two new varieties of geotextiles namely Class 1R (for their application on top of subgrade or prepared subgrade before laying blanket or anywhere within the embankment) and Class 2R (for their applications below the ballast and above the blanket layer) have been included in this standard on the recommendation of RDSO, Lucknow to extend the applicability of standard for railway applications. In this revision, considerable assistance has been derived from RDSO/2018/GE: IRS-0004 — Part-I 'Specification of non-woven geotextile to be used as separator/filtration in railway formation' published by RDSO, Lucknow.

Geotextiles, primarily made from polyester (PET) or polypropylene (PP), are classified into two main types that is woven and nonwoven. Knitted and stitch bonded geotextiles are occasionally used in manufacturing of specialty products. Nonwoven geotextiles are preferably used for subsurface in plane and normal to plane drainage, as well as for erosion control applications and road stabilization over moisture sensitive soils. Among woven geotextiles, slit film fabrics geotextiles are commonly used for sediment control, that is silt fence and road stabilization applications but are poor choices for subsurface drainage and erosion control applications. Monofilament woven geotextiles have better permeability making them suitable for certain drainage and erosion control applications. High strength multifilament woven geotextiles are primarily used in reinforcement applications.

Survivability of geotextiles is very important from the viewpoint of their long-term durability and is defined as resistance to mechanical damage during construction and initial operation. The ability of a geosynthetic to survive installation, reasonable service loads and associated pressures during the service shall be assured if it is to perform as designed. Installation damage to a geotextile is a function of the followings:

a) Geotextile thickness;

b) Type and weight of construction equipment used for fill spreading;

c) Grain size distribution of backfill;

d) Angularity of backfill;

e) Polymer used in the manufacture of geotextile; and

f) Geotextile manufacturing process.

The followings are the major applications of geotextiles:

a) Subsurface drainage and filtration:

Effective drainage is vital for structures like buildings, pavements, embankments, retaining walls and other structures. Traditional drainage media using graded aggregates can now be replaced with geosynthetics, offering a cost-effective and efficient solution. The traditional methods of subgrade dewatering by digging a trench, providing a coarse aggregate drainage layer or a pipe system or use of fine sand as a filter are time consuming and may provide inconsistent properties. Geotextiles are being used in lieu of select grades of sand for lowering the water table and act as graded filter to prevent piping of subgrade soil because they provide consistent properties and, they are easy to install. These are used in toe drains of embankments where they are easily accessible, if maintenance is required and where malfunction can be detected. The excellent filtration and separation characteristics associated with filtration geotextiles permits the use of a single layer of an open graded aggregate enveloped in a geotextile.

Geotextiles are permeable separators to retain soil or other particles subjected to hydrodynamic forces while allowing the passage of fluids into or across a geotextile and to prevent migration of adjacent soil layers. The primary geotextile characteristics affecting filter functions are opening size, flow capacity and clogging potential which are indirectly measured by the apparent opening size (AOS), permittivity and gradient ratio test. The geotextile shall also have the strength and durability to survive construction and long-term conditions for the design life of the drain. Additionally, construction methods have a critical effect on geotextile drain performance.

b) Subgrade deparation and stabilization:

Geotextiles and geogrids are the most cost-effective materials for safeguarding roads and pavements. Geotextiles extend the service life of roads, increase their load-carrying capacity, and reduce rutting. When serving as a separator, the geotextile prevents fines from migrating into the base course and/or prevents base course aggregate from penetrating into the sub-grade. The soil retaining properties of the geotextile are basically the same as those required for drainage and filtration. Therefore, the retention and permeability criteria required for drainage shall be met. In addition, the geotextile shall withstand the stresses resulting from the load applied to the pavement. The nature of these stresses depends on the condition of the sub-grade, type of construction equipment and the cover over the sub-grade. Since the geotextile serves to prevent aggregate from penetrating the sub-grade, it shall meet puncture, grab and tear strengths required.

At small rut depth, the strain in the geosynthetic is also small. In this case, the geosynthetic acts primarily as a separator between the soft sub-grade and the aggregate. Any geosynthetic that survives construction shall work as a separator. This application is limited to soils which either in initially or seasonably have a CBR > 3 but < 8. In this application the geotextile is a substitute for the choked subbase stone commonly used over plastic sub-grades. It is important to understand that this function may be required when geogrids are used to provide base reinforcement or confinement.

For larger rut depths, more strain is induced in the geosynthetic where the stiffness properties of geosynthetic are essential. A considerable reduction in aggregate thickness is possible by the use of geosynthetic having a high modulus in the direction perpendicular to the road centerline; however, the benefits of the geosynthetics are dependent on the membrane action achieved with a stiff geosynthetic as well as the lateral movement. For very weak sub-grades, it is often beneficial to combine the benefits of both separation and stabilization. The following general conclusion can be drawn relating to a typical road base:

1) A geosynthetic element that functions primarily as a separator (typically when the sub-grade CBR > 3) will increase the allowable bearing capacity of the sub-grade by 40 percent to 50 percent (separation geotextiles); and
2) A geosynthetic element that functions primarily to provide confinement of the aggregate and lateral restraint to the sub-grade (typically when the sub-grade CBR < 3) will both increase the allowable bearing capacity of the sub-grade and provide an improved load distribution ratio in the aggregate. The combined benefits can enhance load carrying capacity of the road by well over 50 percent (stabilization geogrids and geotextiles).

The general rules for use of geogrids and geotextiles in roadway system are as follows:

1) *Temporary roads* — Used for hauling and access roads that are subject to low volume of traffic including working platform for permanent road construction:

   i) *Clayey or silty subgrade with California bearing ratio* (*CBR*) < 4 — If a clean base aggregate is used, then a non-woven separator geotextile shall be used. If a "choked aggregate" like general crusher run is used, then use either a geotextile or a biaxial geogrid that has good aperture stability and appropriate size. For a design equivalent single axle loading (ESAL) less than 1 000, a woven geotextile designed for both separation and membrane roles may be used; that is, consider the geotextile's modulus. For larger ESAL, use a woven or non woven geotextile designed simply for separation. The reinforcement role of the geogrid seems safe for approximately 10 000 ESAL.

   ii) *Sandy subgrade with CBR* < 3 — Select a biaxial geogrid with good aperture stability and appropriate size or, a woven geotextile that has a reasonable interface friction with the sand and the aggregate. If a woven geotextile is considered, care should be taken to ensure that it does not actually create a slick slip- plane beneath the aggregate, that is, look at the interface friction by using geotextiles with high surface roughness which leads to enhanced interface friction.

2) *Permanent roads* (*ESAL* > 200 000):

   i) *Clayey or silty subgrade with CBR* < 3 — Consider building a working platform using the temporary roadmethods upon which conventional road can be constructed;

   ii) *Clayey or silty subgrade with* 3 < *CBR* < 8 — If there is any potential for degradation due to water intrusion, frost heave, etc. then include a separator geotextile to protect the base aggregate during these periods; and

   iii) *Sandy subgrades with CBR* < 3 — Use a biaxial geogrid that has good aperture stability and appropriate size to reinforce the base aggregate. This is particularly helpful when poor quality aggregate and base having thickness less than 250 mm is used.

c) Erosion control in hard armor systems:

Soil banks or slopes exposed to constant concentrated flows, currents or waves cannot support vegetation and thus need to be protected from erosion by hard armor systems. These systems include fabric formed revetments, gabions, revet mattresses, interconnected concrete blocks and riprap.

In a hard armor system, water can seep in or out of the bank or slope and gradually carries soil particles with it creating voids causing loss of armor support over time called piping and thus culminates in shifting, rolling or other instability in the armor system. Traditional methods involving graded sand filters can be costly and challenging, especially on steep slopes.

Geotextiles with specific hydraulic and soil retention properties to complement the soil needing protection can be used as standard filter layers for hard armor systems as these can be installed with ease on slopes even under water and are cost effective. Depending upon the gradation of the bank soil, either a non-woven or a woven geotextile can be selected and used beneath hard armor system in an erosive environment. The primary function of geotextile in erosion control applications is filtration. Geotextile filtration properties are a function of site hydraulic conditions and the in-situ soil gradation, density, and plasticity.

d) Separation/filtration in railway formation:

The passage of the train on the rail causes movement of sleeper and ballast. As a result, fines from the subgrade may be pumped upward into the granular layers, reducing the strength and the drainage capacity of ballast. When ballast is placed directly over a clay or silty subgrade, slurry formation can occur at the ballast subgrade interface, especially in depressions or pockets, as the ballast oscillates with axle load cycles. This oscillation under loaded conditions disturbs the underlying clay or silt, and in the presence of water, a slurry forms and is pumped upward into the ballast voids.

Geotextiles whether used individually or in combination with other geosynthetics address these challenges by reducing the penetration of granular particles into a soft subgrade, thereby maintaining the thickness and integrity of the granular layers and increasing railway track life time. To provide this function, the geosynthetic must be resistant to concentrated stresses (tear, puncture and burst) and have aperture sizes compatible with the particle sizes of the material to be retained.

These products also offer effective alternative to traditional solutions like use of graded sub-ballast or natural mineral blanket laid on the subgrade to act as filter/separator and prevent pumping. Unlike sand, geosynthetics are compact, making them easier to transport and quicker to install. They are rapidly laid ready for ballast placement. They provide consistent, factory-controlled properties, eliminating the need for precise thickness across the railway track, which is essential while using sand. Additionally, using geotextiles instead of a sand layer reduces the need for excavation and soil disposal. To effectively perform filtration function, geotextiles must possess sufficient permeability, retention properties, and resistance to clogging, enabling water to pass through freely while retaining subgrade solid particles.

The composition of the Committee responsible for the formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GEOSYNTHETICS — GEOTEXTILES FOR SUBSURFACE DRAINAGE, SUBGRADE SEPARATION, SUBGRADE STABILIZATION, FILTRATION AND EROSION CONTROL (IN HARD ARMOR SYSTEMS) APPLICATIONS — SPECIFICATION

(Second Revision)

1 SCOPE

This standard specifies general and performance requirements for geotextiles made from polyolefins, polyesters or polyamides material used in:

a) subsurface drainage, subgrade separation, subgrade stabilization, erosion control applications (in hard armor systems); and

b) separation/filtration application in railway formation on top of subgrade or prepared subgrade before laying blanket or anywhere within the embankment or used below the ballast and above the blanket layer.

NOTES

1 This is a material specification and design review of its use for intended applications is recommended. Subsurface drainage and filtration, separation, stabilization, and erosion control (in hard armor systems), are site specific design issue which should be addressed by engineer in charge. The engineer should address the following specifics:

i) *Subsurface drainage* — geotextile type, structure and associated details, shall be as shown on the contract drawings;

ii) *Subgrade separation* — geotextile type, cover material thickness, pavement cross-section and associated details, shall be as shown on the contract drawings;

iii) *Subgrade stabilization* — geotextile type, cover material thickness, pavement cross-section and associated details, shall be as shown on the contract drawings; and

iv) *Erosion control in hard armor systems* — geotextile type and thickness, slope steepness, fill thickness and associated details, shall be as shown on the contract drawings.

2 This specification is not applicable for embankment reinforcement where stress conditions may cause global failure.

3 This standard and specification are based on the minimum requirements of the geotextile to provide drainage, filtration, erosion control, stabilization, and survivability during installation. The physical properties listed in Table 2 and Table 3 are applicable for a minimum backfill thickness of 150 mm. However, in general, the geotextile shall be placed as detailed in contract drawing. Unless otherwise specified in the project specification, the contractor shall follow the construction/installation guidelines in the relevant Indian Standard.

4 Additionally, the specification includes default geotextile selection criteria related to erosion control in hard armor layer for varying severity conditions of armor layer stone weights and drop heights, with or without an aggregate bedding layer:

a) Armor layer stone weights do not exceed 100 kg, stone drop height is less than 1 m and no aggregate bedding layer is required; and

b) Armor layer stone weights exceed 100 kg, stone drop height is less than 1 m and the geotextile is protected by a 150 mm thick aggregate bedding layer designed to be compatible with the armor layer.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 13321 (Part 1) and following definitions shall apply:

3.1 Erosion Versus Sedimentation — Erosion occurs when soil particles are displaced due to the impact of raindrops, moving water or wind. Sedimentation occurs when eroded particles (sediments), carried by water or wind, are deposited in another location where they can cause problems. Clearly, sediments (suspended eroded particles) and sedimentation (redeposited soil particles) cause the problems commonly associated with erosion. Erosion control can prevent problems from ever starting. Sediment control can only attempt to minimize the extent of these problems.

3.2 Filtration — The long-term free flow of water from the subgrade through the geotextiles into a subsurface drain system retaining the *in-situ* soil solid particles

3.3 Minimum Average Roll Value (MARV) — The average value of roll minus two times the standard deviation. Statistically, it yields a 97.7 percent degree of confidence that any sample taken during quality assurance testing shall exceed value reported.

3.4 Sub-Grade Improvement — The improvement of the bearing capacity and mitigation of deformation of the sub-grade soil by placing a geotextile immediately over a soft sub-grade soil. The goal of this application may be to reduce undercut requirements, improve construction efficiency, reduce the amount of aggregate subbase/base material required, provide a stiff working platform for pavement construction, or combination of these.

3.5 Traffic Benefit Ratio (TBR) — Also known as Traffic Improvement Factor (TIF), it is the ratio of reinforced load cycles to failure (excessive rutting) to the number of cycles that cause failure of an unreinforced road section. Thus, it compares the performance of a pavement cross-section with a geotextile-reinforced base course to a similar cross-section without geotextile reinforcement, based on the number of cycles to failure. The failure is defined as a selected depth of rut through repetitive loading applied by a passing wheel load of at least 2 041.2 kg (4 500 lbs) per single wheel or 4 082.4 kg (9 000 lbs) per dual wheel.

4 MATERIALS

4.1 The geotextiles shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties.

4.2 Polymers used in the manufacture of geotextiles, and the mechanical fasteners or threads used to join adjacent rolls, shall consist of long chain synthetic polymers, composed of at least 95 percent by weight of polyolefins (polyethylene or polypropylene), polyesters or polyamides when tested as per dissolution method in respective solvents as specified in IS 667. They shall be formed into a stable network such that the ribs, filaments or yarns retain their dimensional stability relative to each other, including selvedges. Polyolefin material shall be UV stabilized by adding suitable UV stabilizer and/or carbon black. Polyolefin material, if manufactured by using carbon black shall contain 2 percent to 3 percent of carbon black by mass with satisfactory dispersion.

Only virgin polymers shall be used in the manufacturing of geotextiles, recycled polymers shall not be used in the manufacturing of geotextiles. In case of polyester geotextiles, the isophthalic acid content of the virgin polyester shall be nil when tested according to the method prescribed in Annex B.

4.3 Geotextiles shall be dimensionally stable and able to retain their geometry under manufacture, transport and installation. Woven slit film geotextiles (that is, geotextiles made from yarns of a flat, tape-like character) shall not be used.

5 STRENGTH AND DURABILITY REQUIREMENTS FOR GEOTEXTILES USED IN SUBSURFACE DRAINAGE, SUBGRADE SEPARATION, SUBGRADE STABILIZATION, EROSION CONTROL (IN HARD ARMOR SYSTEMS) APPLICATIONS

5.1 Geotextiles shall be of following three classes depending upon the survivability conditions:

a) *Class* 1H — For severe or harsh survivability conditions, where there is a greater risk for geotextile damage;

b) *Class* 2H — For typical survivability conditions; this is the default classification to be used in the absence of site-specific information; and

c) *Class* 3H — For mild survivability conditions, where there is lower risk of geotextile damage.

5.2 The geotextiles used for subsurface drainage, subgrade separation, subgrade stabilization and erosion control (in hard armor systems) applications shall meet the strength and durability requirements as given in Table 1 and specific requirements as given in **6**, based on their applications.

NOTES

1 All numeric values in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6 except apparent opening size (AOS), represent MARV in the weakest principal direction. Values for AOS represent maximum average roll values.

2 The property values in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6 represent default values which provide for sufficient geotextile reinforcement and survivability under most construction conditions.

3 Average of test results from any sampled roll in a lot shall meet or exceed the minimum values specified in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6.

6 SPECIFIC REQUIREMENTS BASED ON APPLICATIONS

6.1 Subsurface Drainage Applications

6.1.1 The function of subsurface drainage refers to placing a geotextile against a soil to allow for long term passage of water into a subsurface drain system retaining the in-situ soil. The primary function of the geotextile in subsurface drain system is filtration. Geotextile filtration properties are a function of the in-situ soil gradation, plasticity and hydraulic conditions.

6.1.2 The geotextiles used for subsurface drainage applications shall meet the requirements as given in Table 1 and Table 2.

6.2 Subgrade Separation Applications

6.2.1 The function of separation in this application refers to using a tensile member in the form of a geotextile between the aggregate cover material and the soft subgrade soil with the intent of either increasing the structural support capacity of that component of the pavement structure and hence its life or reduce the initial cost. The geotextile separator may provide one or more of the following functions:

a) A filter to allow water but not soil to pass through it;

b) A separator to prevent the mixing of the soft soil and the granular material; and

c) A reinforcement layer to resist the development of rutting.

6.2.2 The separation application is appropriate for pavement structures constructed over soils with California bearing ratio greater than or equal to three (CBR $\geq$ 3) and shear strength greater than approximately 90 kPa. It is appropriate for unsaturated sub-grade soils. The primary function of a geotextile in this application is separation.

6.2.3 The geotextiles used for subgrade separation shall meet the requirements as given in Table 1 and Table 3.

6.3 Subgrade Stabilization Applications

6.3.1 The function of stabilization in this application refers to using a tensile member in the form of a geotextile between the aggregate cover material and the soft subgrade soil with the intent of either increasing the structural support capacity of that component of the pavement structure and hence its life or reduce the initial cost. The geotextile may also serve to stabilize the sub-grade provided the geotextile conforms to the requirements for separation and filtration as prescribed in relevantspecifications. The stabilization function of geotextile is applicable to pavement structures constructed over existing subgrade soils with a California bearing ratio between 1 and 3 ($1 < CBR < 3$), and shear strength between approximately 30 kPa to 90 kPa. The stabilization application is appropriate for subgrade soils which are saturated due to a high ground water table or due to prolonged periods of wet weather.

6.3.2 The geotextile for the purpose of subgrade stabilization shall meet the requirements as given in Table 1 and Table 4.

6.4 Erosion Control Applications in Hard Armor Systems

6.4.1 The function of erosion control in this application refers to use of geotextile between energy absorbing armor systems and the *in-situ* soil to prevent the soil loss resulting in excessive scour and to prevent hydraulic uplift pressures causing instability of the erosion control systems.

NOTE — This standard does not apply to other types of geosynthetic erosion control materials such as turf reinforcement mats.

6.4.2 The primary function the geotextile serves in erosion control applications is filtration. Geotextile filtration properties are a function of hydraulic conditions and in situ soil gradation.

6.4.3 The geo-textiles used for erosion control applications in hard armor systems shall meet the requirements as given in in Table 1 and Table 5.

7 REQUIREMENTS FOR GEOTEXTILES USED IN SEPARATION/FILTRATION APPLICATIONS IN RAILWAY FORMATION

7.1 The non-woven geotextiles to be used as separator/filtration layer (primary role as separator and secondary role as filtration) in railway application are either used on top of subgrade or prepared subgrade before laying blanket or anywhere within the embankment or used below the ballast and above the blanket layer. The non-woven geotextile used as separator/filtration application shall be of following two types:

a) *Class* 1R — Geotextiles which are used on top of subgrade or prepared subgrade before laying blanket or anywhere within the embankment; and

b) *Class* 2R — Geotextiles which are used below the ballast and above the blanket layer.

Table 1 Strength and Durability Requirements for Different Classes of Geotextiles

(*Clauses* 5.2, 6.1.2, 6.2.3, 6.3.2, 6.4.3, 8.4 *and Tables* 2, 3, 4, 5)

Sl No.	Characteristic	Requirements						Method of Test, Ref to
		Class 1H		Class 2H		Class 3H		
		Strain < 50%	Strain > 50%	Strain < 50%	Strain > 50%	Strain < 50%	Strain > 50%	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	Index Properties							
a)	Type of geotextile	Woven/non-woven						Visual
b)	Roll length, m, *Min*	50 or 100 or as agreed						IS 1954
c)	Roll width, m, *Min*	2.0 or 5.0 or as agreed						IS 1954
d)	Grab strength, N, *Min*	1 400	900	1 100	700	800	500	IS 16342
e)	Sewn seam strength, N, *Min* (*see* Note 1)	1 200	810	990	630	720	450	IS 15060
f)	Trapezoidal tear strength, N, *Min*	500	350	400	250	300	180	IS 14293
g)	CBR puncture strength, N, *Min*	2 800	2 000	2 200	1 400	1 700	1 000	IS 16078
h)	Abrasion strength (*see* Note 2)	550	400	350	—	—	—	IS 14714
ii)	Durability Properties							
a)	Resistance to installation damage, percent retained strength, SC/SW/GP (*see* Note 3), *Min*	95/93/90						IS 17420
b)	Ultraviolet stability at 500 h, retained strength, percent of original strength, *Min*	70						IS 13162 (Part 2)

NOTES

1 The parameter shall be tested, when product is supplied with seam. Refer to IS 16343, IS 16344, IS 16345 and IS 16363 for stitch and overlap seam requirements based on the different geotextile applications.

2 Abrasion strength shall be tested for the geotextiles used in erosion control applications only. After abrading the geotextiles for 250 cycles, the grab strength shall be calculated by the method specified in IS 16342.

3 Resistance to installation damage (loss of load capacity or structural integrity) when subjected to mechanical installation stress in clayey sand (SC), well graded sand (SW) and crushed stone classified as poorly graded gravel (GP).

4 Class 2 geotextiles may be specified for trench drain application based on field experience, laboratory testing and visual inspection of a geotextile sample removed from a field test section or when the subsurface drain depth is less than 2 m and drain aggregate is less than 30 mm.

Table 2 Requirements of Geotextiles for Subsurface Drainage Applications

(*Clauses* 1, 5.2, 6.1.2 *and* 8.4)

Sl No.	Characteristics	Requirements			Method of Test, Ref to
		Course Soil	Medium Soil	Fine Soil	
(1)	(2)	(3)	(4)	(5)	(6)
i)	Geotextile class	Class 2H or Class 3H			*see* Table 1
ii)	Permittivity[1)], s^{-1}, *Min*	0.5	0.2	0.1	IS 14324
	AOS[2,3)], mm, *Max*	0.425	0.250	0.212[3)]	IS 14294

[1)] In addition to default permittivity value, the engineer may require geo-textile permeability and/or performance testing in problematic soil environments.

[2)] Site specific geo-textile design should be performed, if unstable or highly erodable soils such as non-cohesive silts; gap-graded soils; alternating sand/silt laminated soils; dispersive clays; and/or rock flour are encountered.

[3)] For cohesive soils with a plasticity index greater than 7, minimum average roll value shall be 0.30 mm.

Table 2 (*Concluded*)

NOTE — The structural integrity properties of geotextile is affected by the *in-situ* soil gradation. Geotextile fabric selection is determined by the presence of coarse, medium, or fine soil particles at the installation site. Soil classification into these categories is based on the percentage of particles passing through a 0.075 mm (200 mesh) sieve:

a) Course soil: *In situ* soil passing < 15 percent;
b) Medium soil: *In situ* soil passing 15 percent to 50 percent; and
c) Fine soil: *In situ* soil passing > 50 percent.

Table 3 Requirements of Geotextiles Used in Subgrade Separation Applications

(*Clauses* 1, 5.2, 6.2.3 *and* 8.4)

Sl No.	Characteristic	Requirements	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Geo-textile class	Class 2H or Class 3H	*see* Table 1
ii)	Permittivity, s^{-1}, *Min*	0.02	IS 14324
iii)	AOS, mm, *Max*	0.600	IS 14294

NOTE — Permittivity of the geotextile should be greater than that of the soil.

Table 4 Requirements of Geotextiles used in Subgrade Stabilization Applications

(*Clauses* 5.2, 6.3.2 *and* 8.4)

Sl No.	Characteristic	Requirements	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Geotextile class	Class 1H or Class 2H or Class 3H	*see* Table 1
ii)	Permittivity, s^{-1} , *Min*	0.05	IS 14324
iii)	AOS, mm, *Max*	0.425	IS 14294

NOTE — Permittivity of the geo-textile should be greater than that of the soil.

Table 5 Requirements of Geotextiles Used in Erosion Control Application in Hard Armor Systems

(*Clauses* 5.2, 6.4.3 *and* 8.4)

Sl No.	Characteristic	Requirements			Method of Test, Ref to
		Course Soil	Medium Soil	Fine Soil	
(1)	(2)	(3)	(4)	(5)	(6)
i)	Geotextile class	Class 1H or Class 2H			*see* Table 1
ii)	Permittivity, s^{-1} , *Min*	0.7	0.2	0.1	IS 14324
iii)	AOS, mm, *Max*	0.425	0.250	0.212[1)]	IS 14294

[1)] For cohesive soils with a plasticity index greater than 7, maximum average roll value for apparent opening size for geotextile material shall be 0.3 mm.

Table 5 (*Concluded*)

NOTE — The structural integrity properties of geotextile is affected by the in-situ soil gradation. Geotextile fabric selection is determined by the presence of coarse, medium, or fine soil particles at the installation site. Soil classification into these categories is based on the percentage of particles passing through a 0.075 mm (200 mesh) sieve:

a) Course soil: In situ soil passing < 15 percent;

b) Medium soil: In situ soil passing 15 percent to 50 percent; and

c) Fine soil: In situ soil passing > 50 percent.

Table 6 Requirements of Geotextiles for Separation/Filtration Applications

(*Clauses* 5.2, 7.2 *and* 8.4)

Sl No.	Characteristic	Requirements		Method of Test, Ref to
		Class 1R	Class 2R	
(1)	(2)	(3)	(4)	(5)
i)	**Index properties**			
a)	Type of geotextile	Non-woven (needle punched and mechanically or thermally bonded type or equivalent)		—
b)	Roll length, m, *Min*	50 or 100 or as agreed		—
c)	Roll width, m, *Min*	5.0 or as agreed		—
d)	Elongation at break, Percentage, *Min*	50		IS 16342
e)	Grab strength, N, *Min*	700	1 750	IS 16342
f)	Trapezoidal tear strength, N, *Min*	250	800	IS 14293
g)	CBR puncture strength, N, *Min*	1 800	5 800	IS 16078
ii)	Hydraulic Properties			
a)	Apparent opening size, mm, *Max*	0.850		IS 14294
b)	Water flow rate normal to the plane, $l/m^2/s$, *Min*	20		IS 17179
iii)	Durability Properties			
a)	Abrasion strength, percentage retained strength in breaking load, *Min*	80		IS 14714
b)	Resistance to UV light weathering, Percentage retained strength in breaking load after 500 h UV exposure, *Min*	70		IS 13162 (Part 2)
c)	Minimum retained ultimate tensile strength (for 100 years service life), percent (*see* Note)	50		Annex C

NOTE — In such circumstances, if it is not possible to cover the geotextile within two weeks, adequate protection/cover shall be provided to protect the geotextiles against UV exposure.

7.2 The non-woven geotextile used as separator/filtration application in railway formation shall meet the requirements as given in Table 6.

8 SAMPLING AND CRITERIA FOR CONFORMITY

8.1 Lot

The quantity of the same class of geotextile manufactured from the same polymer under identical conditions and supplied to a buyer against one dispatch note shall constitute a lot.

8.2 Sampling for tests shall be done in accordance with IS 14706 from each lot. Acceptance shall be based on testing of conformance samples obtained using procedure given in IS 14706.

8.3 Testing of samples shall be performed in accordance with the methods referred to in this standard for the indicated requirement(s). The number of specimens to test shall be as specified in each test method. Product acceptance shall be determined by comparing the average test results of all the specimens within a given sample to the specified MARV.

8.4 Criteria for Conformity

The geotextile shall be tested for all the requirements as specified in Table 1 or Table 2 or Table 3 or Table 4 or Table 5 or Table 6 and **4.1** to **4.3** of this standard. When any individual sample fails to meet any specification requirement, that roll shall be rejected and two additional sample rolls shall be selected from the same lot. The lot shall be declared conforming to the requirements of this standard, if neither of these two additional samples fails to comply with any part of this specification, otherwise the entire quantity of rolls represented by that sample shall be rejected.

9 MARKING AND LABELLING

9.1 The geotextile material shall be marked with the following by attaching the printed labels:

a) Manufacturer's name, initials or trade-mark;

b) Identification of the geotextile material as per manufacturer's recommendation, for example, polyester multifilament woven geotextile for erosion control;

c) Class of geotextile material, that is Class 1H, Class 2H or Class 3H, Class 1R or Class 2R;

d) Batch number, lot number and roll number;

e) Date of manufacture of geotextile material;

f) Roll length and width;

g) The country of origin; and

h) Any other information/instruction prescribed by the manufacturer or by the law in force.

9.2 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per theconformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the product(s) may be marked with the Standard Mark.

10 PACKING

The geotextile shall be packed in rolls or as per the contract or order. Each roll or package shall be protected by wrapping it in a LDPE film of suitable thickness to prevent it from the adverse impact of heat and moisture, oil, grease, dirt, dust and other stains during shipment and storage prior to deployment.

11 INFORMATION AND SAMPLES TO BE SUBMITTED BY THE MANUFACTURER

The manufacturer shall submit to the purchaser the following:

a) Geotextile product sample approximately one square metre or larger;

b) Geotextile product data sheet and certification from himself or by third party certification such as the use of the Standard Mark stating that the geotextile product supplied meets the requirements of this standard; and

c) Manufacturer's installation instructions and general recommendations.

12 STORAGE AND PROTECTION

12.1 During storage, elevate the geotextile rolls off the ground and adequately protect them from the following:

a) Site construction damage;

b) Excessive precipitation;

c) Extended exposure to sunlight;

d) Aggressive chemicals;

e) Flames or temperatures in excess of 71 °C;

f) Excessive mud, wet concrete, epoxy, or other deleterious materials coming in contact with and affixing to the geotextile material; and

g) Any other environmental condition that may damage the physical property values of reinforcement.

12.2 Store the geotextile material at temperatures above – 20 °C.

12.3 Lay the rolled materials flat or vertical on ends.

12.4 Do not leave the geotextile material directly exposed to sunlight for a period longer than the period recommended by the manufacturer.

12.5 Each geotextile roll shall be wrapped with a material that will protect it from damage due to shipment, water, sunlight and contaminants.

12.6 Keep geotextile dry until installation, and do not store directly on the ground.

ANNEX A

(*Clause 2*)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 667 : 1981	Methods for identification of textile fibres (*first revision*)
IS 1070 : 2023	Reagent grade water — Specification (*fourth revision*)
IS 1954 : 2024/ ISO 22198 : 2006	Textiles — Fabrics — Determination of width and length (*third revision*)
IS 1966 (Part 2) : 2022/ISO 13938-2 : 2019	Textiles — Bursting properties of fabrics: Part 2 : Pneumatic method for determination of bursting strength and bursting distension (*third revision*)
IS 13162	Geotextiles — Methods of test:
(Part 2) : 1991	Determination of resistance to the exposure of ultraviolet light and water (xenon-arc type apparatus)
(Part 4) : 1992	Determination of puncture resistance by falling cone method
IS 13321 (Part 1) : 2022/ISO 10318-1 : 2015	Geosynthetics — Part 1 : Terms and definitions (*first revision*)
IS 14293 : 1995	Geotextiles — Method of test for trapezoid tearing strength
IS 14294 : 1995	Geotextiles — Method for determination of apparent opening size by dry sieving technique
IS 14324 : 1995	Geotextiles — Methods of test for determination of water permeability — permittivity
IS 14706 : 1999	Geotextiles — Sampling and preparation of test specimens
IS 14714 : 1999	Geotextiles — Determination of abrasion resistance
IS 15060 : 2018/ ISO 10321 : 2008	Geosynthetics — Tensile test for joint seams by wide-width strip method (*first revision*)
IS 16078 : 2013/ ISO 12236 : 2006	Geosynthetics — Static puncture test (CBR test)
IS 16342 : 2015	Geosynthetics — Method of test for grab breaking load and elongation of geotextiles
IS 16343 : 2015	Geosynthetics — Guidelines for installation of geotextiles as pavement fabric
IS 16344 : 2015	Geosynthetics — Guidelines for installation of geotextile for permanent erosion control in hard armor systems
IS 16345 : 2020	Geosynthetics — Guidelines for installation of geotextile used in subgrade separation in pavement structures (*first revision*)
IS 16363 : 2015	Geosynthetics — Guidelines for installation of geotextile used in subsurface drainage application
IS 17179 : 2019 ISO 12958 : 2010	Geotextiles and geotextile-related products — Determination of water flow capacity in their plane
IS 17360 : 2020 / ISO 13438 : 2018	Geosynthetics — Screening test method for determining the resistance of geotextiles and geotextile-related products to oxidation
IS 17420 : 2020/ ISO 10722 : 2019	Geosynthetics — Index test procedure for the evaluation of mechanical damage under repeated loading — Damage caused by granular material (laboratory test method)

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ANNEX B

(*Clause* 4.2)

METHOD OF TEST FOR ISOPHTHALIC ACID CONTENT OF THE VIRGIN POLYESTER FIBRE

B-1 PRINCIPLE

This method is applicable to measure isophthalic acid content in polyethylene terephthalate sample. The polymer sample is digested in benzyl alcohol, depolymerized then esterified to dibenzyl isophthalate, dibenzyl terephthalate and glycols. Isopropyl titanate is added as a depolymerization catalyst. The sample is analyzed by gas chromatography and the peak areas of the two esters are used to estimate the weight percentage dimethyl isophthalate using an internal standard.

B-2 POTENTIAL ENVIRONMENT ISSUE

B-2.1 In case of spillage, it can lead to pollution near the workplace area and environment hazard. After analysis sample is disposed as per laid down procedure.

B-2.2 Hydrogen, nitrogen and instrument air are used during analysis. The hydrogen gas has no adverse ecological effects are expected. Hydrogen does not contain any Class I or Class II ozone depleting chemicals. However, hydrogen is explosive. Gaseous nitrogen is an inert non-flammable gas. High concentration in air may cause deficiency of oxygen with the risk of unconsciousness and death. Chloroform in high concentration in air can kill most animals in few minutes.

B-3 POTENTIAL SAFETY, OCCUPATIONAL HEALTH ISSUES

B-3.1 Proper PPE's like safety goggles, apron, surgical hand gloves to be used.

B-3.2 Glassware is to be handled with care.

B-3.3 Leak check to be carried out while handling of gas cylinder.

B-3.4 Glassware is to be handled with care.

B-3.5 Inhalation of chloroform causes dilation pupils with reduced reaction to light as well as reduced intraocculat pressure. Irritation of mucous membrane, conjunctiva. If contacted with skin and eyes cause irritation. Seek medical advice if inhaled.

B-3.6 Use leather hand gloves while handling hot apparatus and equipment.

B-4 APPARATUS

B-4.1 Gas Chromatograph (GC) — with flame ionization detector

B-4.2 Capillary Column — 60 m length and 0.53 mm

B-4.3 Dispensette or Pipette — 2 ml, 5 ml and 10 ml

B-4.4 Volumetric Flask — 100 ml, 500 ml

B-4.5 Beaker

B-4.6 Funnel

B-4.7 Flask — 50 ml

B-4.8 Heating Mental — to maintain temperature of 250 °C

B-4.9 AR Grade Dimethyl Isopthalate (DMI)

B-4.10 AR Grade Benzyl Alcohol

B-4.11 AR Grade Chloroform

B-4.12 AR Grade Isopropyl Titnate

B-4.13 AR Grade Dimethyl Suburate

B-5 PREPARATION OF STANDARD SOLUTIONS

B-5.1 Stock Dibenzyl Suburate (Internal Standard) Solution

Take (1.0 ± 0.01) g of dimethyl suburate (DMS). Add 100 ml of benzyl alcohol and 6 to 7 drops of isopropyl titnate digest it for 2 h. Allow it to cool up to room temperature then make the volume to 500 ml by carefully rinsing the flask by isopropyl alcohol. Dimethyl suburate will get converted into dibenzyl suburate (DBS). Mark the stock solution as DBS per 2ml ≈ X·XXXX mg

B-5.2 Stock Dimethyl Isopthalate (DMI) Solution

Take (0.2 ± 0.01) g of dimethyl isopthalate (DMI). Add 40 ml of benzyl alcohol and 6 to 7 drops of isopropyl titnate digest it for 2 h. Allow it to cool up to room temperature then make the volume to

100 ml by carefully rinsing the flask by isopropyl alcohol. This will be converted to dibenzyl isopthalate (DBI). Mark the stock solution as DBI per 2 ml ≈ X·XXXX mg.

B-5.3 Standard Solution for Response Factor

Take 2 ml of solution prepared in **B-5.1** and 2 ml of solution prepared in **B-5.2**. Add 10 ml of chloroform.

B-5.4 2.0 Percent Standard IPA Stock Solution

Weigh out accurately (0.200 ± 0.005) g of pure DMI powder into round bottom flask, add 30 ml of benzyl alcohol and 3 drops of isopropyl titante, reflux the solution for 5 h reagent and dilute to 100 g by isopropyl alcohol, calculate actual DMI concentration by considering its purity and label the flask with actual weight taken. Consider this weight during calculation of IPA by GC.

B-5.5 2.0 Percent Standard IPA Solution for GC Injection

Take 2.0 ml IPA stock solution and add 2 ml internal standard (*see* **B-5.1**) and further add 10 ml of chloroform, same bottle to be labelled as 2.0 percent IPA Inject 1 µl in GC.

B-6 CALIBRATION FOR PERFORMANCE CHECK – TWICE/MONTH STANDARD CHIPS

B-7 ANALYTICAL PROCEDURE

Inject 1 µl of standard solution for response factor (*see* **B-5.3**) and calculate response factor. Inject 1 µl of 2 percent standard IPA solution. If value of 2.0 percent standard IPA solution is varying in the range of 0.01 percent, then there is no need for change in response factor. If there is deviation in value then rerun standard solution for response factor (*see* **B-5.3**). Weight (0.2 ± 0.02) g of chips into the round bottom flask. Add 2 ml of benzyl alcohol. Add 3 drops of isopropyl titanate. Digest the solution for 1 h. Allow it to cool up to room temperature. Add 10 ml of chloroform. Add 2 ml of internal standard solution that is solution prepared in **B-5.1** and shake vigorously. Inject 1 µl of sample solution into gas chromatograph.

B-8 CHROMATOGRAPH SETTINGS

Injector temperature	: 300 °C
Detector temperature	: 320 °C
Oven temperature	: 270 °C

Gas flow rates

Nitrogen	: 20 psig
Hydrogen	: 30 ml/min ± 10 ml/min
Air	: 300 ml/min ± 20 ml/min
Attenuation	: – 4
Range	: 1

B-9 CALCULATION

$$\text{Response factor (RF)} = \frac{A_1 \times W_2}{A_2 \times W_1}$$

where

A_1 = area of dibenzyl suburate (DBS) (internal standard) solution;

W_2 = weight of DBI in standard solution, in mg;

A_2 = area of DBI in standard solution; and

W_1 = weight of DBS in solution, in mg.

$$\text{Percent IPA} = \frac{\text{RF} \times \text{mg of internal standard} \times \text{Area of IPA in sample} \times 100}{\text{Weight of sample, in mg} \times \text{Area of internal standard in sample}}$$

ANNEX C

[*Table* 6, *Sl No.* (iii) (c)]

METHOD FOR DETRMINATION OF DURABILITY OF GEOTEXTILES

C-1 GENERAL

C-1.1 Service Life

The provisions and assessment methods of this annex are based upon the intended use of geotextiles, and their foreseen service life in years. They are based upon the current state of the art, knowledge and experience. The service life refers to the period during which the geosynthetic retains the required properties of this annex, assuming it was properly installed, used and maintained. For a geosynthetic which satisfies the requirements of this annex the service life represents a minimum indication. The real service life, for normal conditions of use, may turn out to be considerably longer without major degradation affecting the essential requirements of the works. The indicatedservice life of the geosynthetic cannot be interpreted as a guarantee given by the manufacturer but should be regarded only as a tool for selecting a product suitable for the anticipated working life. The tests described in this annex do not allow the determination of reduction factors. The tests described in this annex are screening tests to show the ability of a product to serve for a certain time. The reference strength and retained strength of products investigated in this annex shall be determined in the same way in accordance with IS 16342.

C-1.2 Initial and Repeat Testing of Durability

C-1.2.1 A product shall be submitted to an initial testing of its durability in accordance with this annex. A product that is unchanged shall be tested again after 5 years. A product is considered unchanged if the raw material supply, the production technology and the process and stabilization of the product have not been subject to a significant process change. If a product has been subject to a significant process change, then it shall be tested in the same manner as a new product.

C-1.2.2 A significant process change is defined as any of the following:

a) a change in the chemical formulation (CAS no);

b) reduced active ingredient concentration levels of raw materials in the polymer recipe; and

c) substitution of any polymer in the recipe, irrespective of any change in concentration.

C-1.2.3 After the durability tests specified in **C-2** the test specimens are subjected to tensile test as per method given in IS 16342. The retained tensile strength is compared to the original tensile strength of reference specimens (result expressed in percentage retained strength).

C-1.2.4 The lightest product variant in a family shall be the variant selected for durability testing. If a manufacturer produces a lighter variant after the initial type testing, it is the responsibility of the manufacturer to decide whether the change is of sufficient magnitude to require the product to be tested as a new product. If the manufacturer decides the change is significant, he shall test the light variant as a new product. If the manufacturer decides this change is not significant, he can use his existing durability data to make a statement for the new product.

C-2 TESTS FOR SPECIFIC MATERIALS

C-2.1 Polyester (PET)

C-2.1.1 A non-reinforcing product consisting solely of PET shall be tested for resistance to internal hydrolysis following test given in Annex D.

C-2.1.2 The minimum retained strength shall be 50 percent.

C-2.2 Polypropylene (PP) and Polyethylene (PE)

C-2.2.1 A product consisting solely of PP or PE shall be tested for resistance to oxidation following IS 17360 (Method A), with the following modifications:

a) The test specimen shall be stored in water (Grade 2 according to IS 1070) at 80 °C for 28 days before testing. The medium shall be changed every 7 day and moved once per day;

b) Test temperature: 100 °C; and

c) Test duration: 112 days.

C-2.2.2 The minimum retained strength shall be 50 percent.

C-2.3 Polyamide (PA)

C-2.3.1 *Oxidation Resistance*

C-2.3.1.1 A product consisting solely of PA-6 or PA-6.6 shall be tested for resistance to oxidation following IS 17360 (Method B) with the following modifications:

a) The test specimen shall be stored in water (Grade 2 according to IS 1070) at 80 °C for 28 days before testing. The medium shall be changed every 7 day and moved once per day;

b) Test temperature: 100 °C; and

c) Test duration: 112 days.

C-2.3.1.2 The minimum retained strength shall be 50 percent.

C-2.3.2 *Hydrolysis Resistance*

C-2.3.2.1 A product consisting solely of PA-6 or PA-6.6 shall be tested for resistance to hydrolysis according to Annex D.

C-2.3.2.2 The minimum retained strength shall be 50 percent.

ANNEX D

(*Clauses* C-2.1.1 *and* C-2.3.2.1)

METHOD FOR DETERMINATION OF RESISTANCE TO HYDROLYSIS IN WATER

D-1 PRINCIPLE

The test and control specimens are immersed in hot water for specified durations and at a specified temperature. The properties of the specimens are determined after immersion. Both the machine and cross machine direction shall be tested unless otherwise agreed.

D-2 REAGENT

Water — according to IS 1070, Class 3

D-3 APPARATUS

D-3.1 Container

Container having the following properties shall be used:

a) The container shall be made of a material which is inert under the conditions of test such as stainless steel or borosilicate glass;

b) The total volume of the test specimens shall not exceed 10 percent of the free space in the container. The test specimens shall be suspended free of significant load and shall be exposed to the test medium on both sides; and

c) The container shall be provided with a means of heating and controlling the temperature to (80 ± 2) °C and a separate means of recording the temperature of the solution.

NOTE — Experience has shown that some types of glass are susceptible to hydrolysis. Make sure to regularly control that no corrosion in the container is occurring.

D-3.2 Thermometer

A thermometer capable of measuring the temperature with an accuracy of ± 1 °C.

D-4 PREPARATION OF THE TEST SAMPLE

D-4.1 Size and Shape

Prepare specimens to the size and shape specified in IS 16342. If the requirements of IS 16342 cannot be met due to container capacity, then the relevant components should be tested individually.

D-4.2 Number of Specimens

Prepare enough specimens to provide a minimum of five test specimens and five control specimens in each test direction.

It is recommended to expose additional specimens in case an extra mechanical test is required (*see* **D-6**).

D-5 PROCEDURE

a) De-ionized water as specified in **D-2** shall always be used in the tests;

NOTE — The quality of the water used as hydrolysing agent in this test is important for the reproducibility of the test results;

b) Expose the test specimens, free of significant load, on both sides to the test medium;

c) The test temperature shall be (80 ± 2) °C and recorded at least once a day;

d) Because shrinkage may occur during the test, all specimens should be mounted in such a way that not significant pre-tension occurs during the exposure to the water;

e) The ratio between the mass of water and the mass of the test specimens shall be at least 30 : 1. Cover the specimens completely with water. Do not treat materials differing in chemical composition in the same enclosure;

f) The test duration for service life of 100 years shall be as follows:

   1) For Polyester (PET) products: 56 days;

   2) For PA-6 or PA-6.6 products: 112 days; and

g) The control specimens shall be exposed to the same environment for 6 hours and then removed and stored in dark at room temperature.

D-6 DETERMINATION OF CHANGES IN PROPERTIES

The test and control specimens shall be conditioned for at least 16 h at (20 ± 2) °C and (65 ± 5) percent relative humidity before evaluation of the desired properties. For type of test method refer to IS 16342.

D-7 TEST REPORT

The test report shall at least include the following information:

a) a reference to this document;

b) a description of the material;

c) the procedure and conditions used;

d) changes in maximum tensile force as defined in IS 16342;

e) date of test; and

f) any deviation from this document or other factors that may influence the result of this test.

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

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