भारतीय मानक

सड़क तथा रेलवे पोतारोहण तथा पहाड़ी ढलान के लिए वर्षा के जल से होने वाले अपरदन हेतु जूट भू ग्रिड

Indian Standard

GUIDELINES FOR APPLICATION OF JUTE GEOTEXTILE FOR RAIN WATER EROSION CONTROL IN ROAD AND RAILWAY EMBANKMENTS AND HILL SLOPES

ICS 45.480 ; 59.080.70

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 2001

Price Group 4

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Water Resources Division Council.

Geotextiles which are being increasingly used in the geotechnical sector of civil engineering are made either of petro-chemical derivatives (synthetic) or of natural fibres. Jute is one such natural fibre out of which jute Geotextiles (JGT) can be made by the special treatment and weaving processes. JGT may be applied with advantage in addressing a number of geotechnical problems.

Jute geotextile being a natural fabric is biodegradable and environment-friendly. It has good hygroscopic and hydrophilic properties. It can absorb moisture up to about 5 times its dry weight and form mulch to promote a quick growth of vegetation. JGT possesses good drapability that is it can shape itself well to the ground topography on which it is laid. It helps control extremes of temperature and thus additionally supports growth of vegetation.

These properties make JGT admirably suitable in areas where natural treatment of a soil surface for control of erosion is called for. Adequate growth of vegetation is possible during the life time of JGT provided the right type of species of vegetation is chosen and planted considering the soil and climatic ambience.

Erosion of railway and road embankments and hill slopes is caused principally by rains and winds. Erosion of the top soil gradually destabilises the earthen embankments. Denuded hill slopes are always vulnerable to erosive forces of rains particularly during the monsoon. JGT when applied on an exposed soil surface acts as miniature check dams or micro terraces, reduces the kinetic energy of rain splashes, diminishes the intensity of surface run-off, prevents detachment and migration of soil particles and ultimately helps in quick growth of vegetation on it by formation of mulch. JGT therefore helps in controlling erosion in road and railway embankments and hill slopes naturally.

There is no ISO Standard on the subject. This standard has been prepared based on the data provided by indigenous manufacturers' and taking into consideration the practices prevalent in the field in India.

The composition of the Committee responsible for formulating this standard is given in Annex C.

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 : 1960 'Rules for rounding off numerical values (*revised*)'. 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

GUIDELINES FOR APPLICATION OF JUTE GEOTEXTILE FOR RAIN WATER EROSION CONTROL IN ROAD AND RAILWAY EMBANKMENTS AND HILL SLOPES

1 SCOPE

This standard gives the guidelines of JGT suitable for application in slopes of road and railway embankments and also in hill slopes including their choice and installation methods.

2 REFERENCES

The following standard contains 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 the standard indicated below :

IS No.	*Title*
1954 : 1990	Method of determination of length and width of fabrics (*second revision*)
1963 : 1981	Methods for determination of threads per unit length in woven fabrics (*second revision*)
1969 : 1985	Methods for determination of breaking load and elongation of woven textile fabrics (*second revision*)
2387 : 1969	Method for determination of weight of jute fabrics (*first revision*)
2405 (Part 1) : 1980	Industrial sieves : Part 1 Wire cloth sieves (*first revision*)
2405 (Part 2) : 1980	Industrial sieves : Part 2 Perforated plates (*first revision*)
4744 : 1991	Textiles — Packaging of jute products in rolls (*first revision*)
7702 : 1975	Method for determination of thickness of woven and knitted fabrics

3 TERMINOLOGY

3.1 For the purpose of these guidelines, the following definitions shall apply.

3.1.1 *Jute Mesh*

Open structured jute geotextile made out of 100 percent jute fibres in which yarns of a specified diameter are laid in specified numbers/length in machine (warp) and cross (weft) directions.

3.1.2 *Roll*

The cylindrical rigid package containing a particular type of JGT rolled on a suitable core and wrapped with a roll covering with its outer layer stitched properly in conformity with IS 4744.

3.1.3 *Lot*

The quantity of JGT of a particular type packed in rolls of a specified length ready for delivery against a dispatch note.

3.1.4 *Contract Weight*

The weight as arrived at in accordance with the relation given in Note (2) under Table 1 from the marked length per roll, nominal width and weight per square metre of JGT.

3.1.5 *Contract Moisture Regain*

It is the percentage regain of moisture by the JGT on the basis of which corrected net weight is calculated.

3.1.6 *Average Moisture Regain*

It is the percentage moisture regain by JGT at the time of preshipment (delivery) inspection calculated on the basis of ten readings per roll.

3.1.7 *Corrected Net Weight*

The weight obtained by adjusting the actual net weight on the basis of average Moisture Regain (**3.1.6**) and Contract Moisture Regain (**3.1.5**).

3.1.8 *Cut (Full Cut)*

The length of JGT continuously woven as specified in the agreement between a buyer and a seller.

3.1.9 *Ends*

The warp threads of a JGT that is the number of threads in a JGT running along the machine direction.

3.1.10 *Picks*

The weft or filling threads of a JGT that is the number of threads along the cross direction (perpendicular to the warp threads).

4 SPECIFIC REQUIREMENTS

4.1 Mechanism of Surface Soil Erosion

As already indicated in the foreword, raindrops cause detachment of the particles of the exposed soil-surface of road and railway embankments and hill slopes by their impact and the detached particles are carried away by the surface run-off and wind. The dislodged particles carry with them seeds and soil-nutrients. Natural growth of vegetation on the slopes is thus hindered. The exposed denuded slopes become increasingly vulnerable to erosion agents and are ultimately destabilised.

4.2 Role of Jute Geotextile in Surface Erosion Control

As already indicated in the foreword, JGT is capable of reducing the erosive effects of rain drops and controlling migration of soil particles of the exposed surface. On biodegradation, JGT forms mulch and fosters quick vegetative growth. Choice of the right type of JGT and plant species is critical for effective results.

Table 1 mentions different types of JGT with their salient properties that can be applied on embankment slopes of roads, railways and of hill to control the erosive effects of natural agents that is rains and wind.

Species of vegetation needs to be selected carefully considering the local soil and climatic conditions. JGT incidently, does not draw upon nitrogenous reserves with its degradation and its fibrous residue improves the soil structure. Trials indicate that JGT has a low C-factor (0.004 for 3 : 1 slope and 0.005 for a 1.5 : 1 slope on plying retention of soil to the extent of 99.6 percent and 99.5 percent respectively). (Ref: 'Erosion Control with Natural Geotextiles' — K. Balan and G. V. Rao — 'Environmental Geotechnology with Geosynthetics 1996'.)

Annex A contains names of plants useful for stabilisation of Bunds, terrace faces and steep slopes and gullies (Ref: "Grasses and Legumes for Forage and Soil Conservation" — K. A. Shankarnarayan and V. Shankar of Central Arid Zone Research Institute, Jodhpur, Rajasthan).

4.3 Selection of JGT

The choice of JGT basically depends on the type of soil to be protected. It requires to be ensured primarily that the slope to be protected from rain water erosion is geotechnically stable.

The selection of JGT is also required to be done in consideration of the extreme rainfall in a limited time span at that location as the intensity of rainfall is more important than the average annual rainfall at a place for assessing Erosion Index and deciding on the choice of a particular type of JGT. No systematic research has been conducted on this aspect as yet. It is recommended that the choice of JGT should be limited to Type 1 (Table 1) where the intensity of rainfall is severe irrespective of the soil-type. Field trials so far conducted have shown that soil mixed with rock grits and boulder-pieces covered with JGT Type I of Table 1 (730 gsm), soil with dominantly sand silt composition and small quantities of clay and/or stone grits protected by JGT Type 2 of Table 1 (500 gsm) while soil with sand and/or clay overlain by JGT Type 3 of Table 1 (292 gsm) have given satisfactory results. The types of JGT mentioned in Table 1 are indicative and provide broad guidelines to the choice of the JGT type by a user. Annex B contains the list of some of the trials and their results for guidance.

5 INSTALLATION METHOD

5.1 The stages of laying of JGT on slopes for rain water erosion control are as under.

5.1.1 The slope should be made free from undulations, soil slurry, mud and sharp projections and compacted with additional earth where necessary.

5.1.2 Anchoring trenches should be excavated at the top and toe of the slope along the length of the embankment. Recommended dimensions of the trench (usually rectangular) are 450 mm deep and 300 mm wide.

5.1.3 The selected JGT should be unrolled across the top trench and along the slope downward, caring to see that it touches the soil surface at all points.

5.1.4 Overlaps should be minimum 150 mm at sides and ends (*see* Fig. 1). The JGT at the higher level on the slope should be placed over the portion to its next at a lower level. Side overlaps of a JGT piece should be placed over its next at a lower level. Side overlaps of JGT piece should be placed over its next piece on one side and under the next piece on the other.

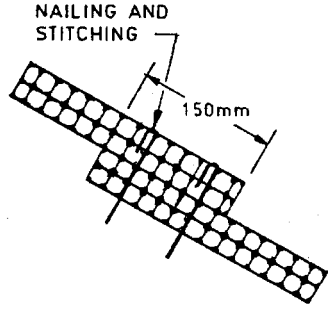

FIG. 1 OVERLAPPING OF JUTE NETTING

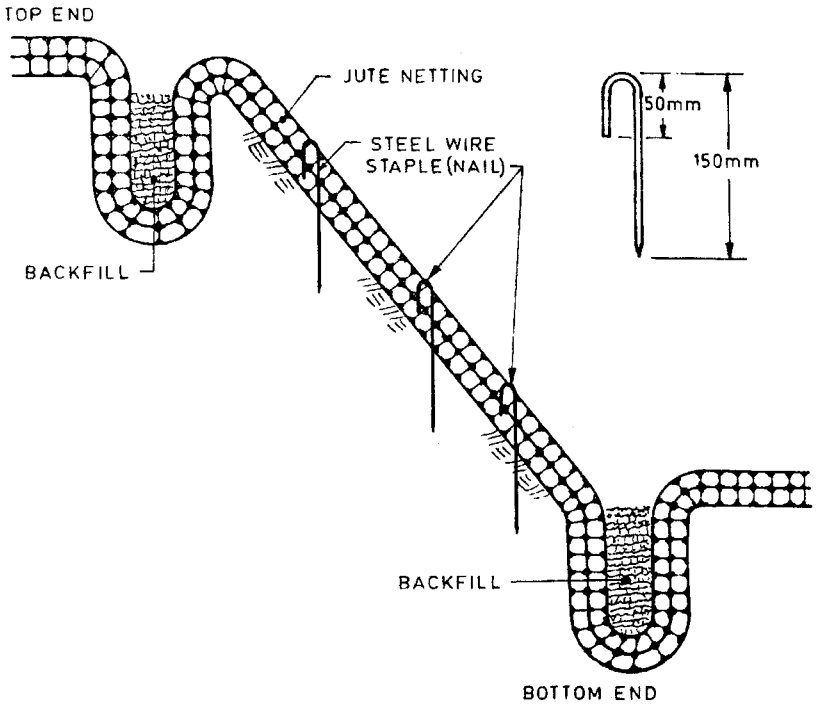

FIG. 2 PLACEMENT OF JUTE NETTING

5.1.5 The JGT should be fixed in position by steel staples as shown in the sketch (usually of 11 gauge dia) or by split bamboo pegs. Stapling should be done normally at an interval of 1 500 mm both in longitudinal and transverse directions. Special care should be taken to staple the JGT within the anchoring trenches both at the bottom and at the sides.

5.1.6 The anchoring trenches should be filled up with brick-bats/soil for preventing displacement of the JGT. Care should be taken that the overlaps are not displaced during installation.

5.1.7 Care should be taken to ensure that the JGT is not damaged due to puncture, tear and other operational stresses.

5.1.8 Seeds of vegetation (grass, legumes, etc, of appropriate variety) should then be spread (refer to Annex A for guidance in selecting the species of vegetation). If seeds are not available, saplings of the appropriate plant species may be planted at suitable intervals through the openings of the JGT.

5.1.9 In special circumstances, a second dose of seeds may be spread with dibbling of locally available grass.

5.1.10 Installation should be completed preferably before the monsoon to take advantage of the rains for quick germination of seeds.

6 MONITORING

6.1 Close monitoring should be done for at least one season cycle.

6.2 The treated area should be kept out of bounds for cattle and other grazing animals till the time of maturity of vegetation.

6.3 The damage and displacement of JGT should be noted for corrective actions. Torn portions of the JGT should be covered with new pieces of JGT of identical specifications duly stapled at all sides.

6.4 Watering/maintenance of the vegetation should be carried out as per specialist advice of agronomist/ botanist.

6.5 Advice should be sought from specialists to find out the cause of unsatisfactory growth of vegetation. The advice should be implemented. Withered plants should be replaced.

7 REQUIREMENTS OF PACKING

7.1 The roll shall satisfy the requirements specified in **7.1.1** to **7.1.5**.

7.1.1 The roll shall be completely covered on all sides excepting the core protrusions which may also be covered if required by the buyer.

7.1.2 A roll may be covered with a polyethylene sheet inside the roll covering if agreed to between the buyer and the seller.

7.1.3 The loose ends of the roll covering shall be sewn with jute twine about 8 cm between stitches on all sides.

7.1.4 At either end, the core shall protrude but not more than 7.7 cm or as agreed to between the buyer and the seller.

7.1.5 The loose end of roll shall be closed with gum tape and also compressed suitably so as to avoid excessive pressure, which may cause damage to the content.

8 MARKING

8.1 Unless otherwise agreed to between the buyer and the seller, the roll shall be stenciled with an indelible ink of any suitable colour with the following:

a) Roll number,
b) Specification including quality and construction,
c) Length of cloth rolled in metres or yards or both as specified by the buyer,
d) The legend 'MADE IN INDIA',
e) Port of entry, and
f) Other declaration required as per law in force.

Table 1 Different Types of JGT

(*Clause* 4.2)

Sl No.	Characteristics	Type 1	Type 2	Type 3	Test Method, Ref to IS
(1)	(2)	(3)	(4)	(5)	(6)
i)	Material	100 percent natural	Jute fibre	—	—
ii)	Construction	Plain weave	—	—	—
iii)	Weight at 20 percent M.R (in gsm)	730	500	292	2387 : 1969
iv)	Maximum length (in metre)	68	68	68	1954 : 1990
v)	Width (in cm)	122	122	122	1954 : 1990
vi)	Ends/dm	7	6.5	11	1963 : 1981
vii)	Picks/dm	7	4.5	12	1963 : 1981
viii)	Thickness (in mm)	7	5	3	7702 : 1975
ix)	Aperture size (in mm)	12 × 12	13 × 20	8 × 7	2405 (Part 1) : 1980 2405 (Part 2) : 1980
x)	Minimum breaking load (in N/10 cm)				
	a) Machine direction (warpway)	1 200	1 040	1 000	1969 : 1985 (*See* Note 1)
	b) Cross direction (weftway)	1 200	790	1 000	1969 : 1985 (*See* Note 1)
xi)	Maximum elongation at break (in percent)				
	a) Machine direction (warpway)	10	11	12	1969 : 1985 (*See* Note 1)
	b) Cross direction (weftway)	12	15	12	1969 : 1985 (*See* Note 1)

NOTES

1 Determination of minimum breaking load and maximum elongation at break as per IS 1969 : 1985 cannot be done on Type 1 and Type 2 fabrics. Indian Jute Industries' Research Association (IJIRA) recommends that these tests on Type 1 and Type 2 fabrics be carried out on Goodbrand Fabric Testing Machine on 20 yarns at random (with at least 20 cm grip length and having the rate of traverse of the machine set at 30 cm/min) to assess the yarn characteristics.

2 Contract weight of roll in kg = $\frac{\text{Nominal Width (cm) (×) Marked length (m)}}{100} \frac{\text{(×) weight (gsm)}}{1\,000}$

3 Correct net weight of roll in kg = net weight (kg percent) $\frac{(100 + \text{Contract Moisture Regain (percent)})}{(100 + \text{Average Moisture Regain (percent)})}$

4 The selected JGT shall satisfy all the requirements mentioned in Table 1.

ANNEX A
(*Clause* 4.2)

PLANTS FOR STABILIZATION OF BUNDS, TERRACE FACES, STEEP SLOPES AND GULLIES
(TEJWANI AND MATHUR, 1974)

(Ref: 'Erosion Control with Natural Geotextiles' — K. Balan and G. V. Rao Type 'Environmental Geotechnology with Geosynthetics 1996)'.

State	*Grass and Legume*	*Yield* (kg/ha)	*Remarks*
Gujarat (Vasad)	*Dichanthium annulatum* *Amphilophis glabra*	385/ha from land under bunds (Verma et al., 1968)	Grass selected on the basis of yield of green forage and soil binding capacity on bunds for aluvial soils (Srinivasan et al., 1962) : *Dichanthium annulatum* was also found best for bench terrace risers
Uttar Pradesh	*Cynodon dactylon* *Dichanthium annulatum* *Cenchrus ciliaris* *Pennisetum purpureum*	4 355 6 805 1 585 33 430	Grasses selected on the basis of length of tap root, spread of root system and for yield alluvial soils near Agra
Western Uttar Pradesh (Saharanpur)	*Eulaliopsis binata*	100/hA bunded area	Near Muzaffarabad (Saharanpur district) 1 ha of bunded area can give 100 kg, it has good binding capacity and is in good demand for paper and rope making
Rajasthan (black soil region Kota)	*Dichanthium annulatum* *Cenchrus ciliaris*	— —	— —
Tamil Nadu (Madhavrao et al., 1968)	*Phalaris tuberosa* *Festuca elatior* *Paspalum dilatatum* *Eragrostis curvula*	— — —	Good soil-binders for terrace faces in hills for elevation of 1 500 m and above and rain-fall of 80-100 cm. Good succulent fodder. do Except for 50-70 cm rainfall
(Venkataraman et al., 1966)	*Cynodon dactylon var* *Suwanne and var. Tiffin* *Pennisetum purpureum* *Chloris gayana* *Urochloa* sp. *Cenchrus ciliaris* *Cenchrus glaucus* *Panicum antidotale* *Tripsacum laxum*	— — — — — — —	Suited to high elevations, good soil binders. Moderate to heavy rainfall hills of medium elevation and plains Low rainfall, hills of medium elevation and plains Good soil-binders for bunds, come up in low rainfall areas Good for making Puerto Rico-type of terraces in the Nilgiri hills
Andhra Pradesh (Ibrahim – patanam)	*Bothriochloa glabra* *B. odorata*	—	Good soil-binding capacity and suitable for stabilizing contour and field bunds
Mysore (Velappan, 1964)	*Tripsacum laxum* (*Guatemala grass*)	22 500	Good fodder in tender stages, good green manure and good soil binder
Stabilization of steep slopes, waste lands, gullies, class V and VII lands			
Bihar (Upper Damodar Catchment)	*Stylosanthes gracili*	19 000 (green)	Perennial legume, very aggressive and suppresses other vegetation, drought resistant, adds a lot of leaf litter (Pandey and Teotia 1969)
Bihar (Upper Damodar Catchment)	*Calopogonium orthocarpum*	—	Deep rooted, perennial, vigorous legume, provides a thick layer of leaf litter, plants

State	*Grass and Legume*	*Yield* (kg/ha)	*Remarks*
			start growth in Feb-Mar and cover the land before onset of monsoon (Pandey, 1966).
Bihar State	Pennisetum pedicellatum	36 000 in 1 cut (green)	Mukherjee and Prasad (1966) have selected 3 promising strains for Bihar; this grassis reported also from Madhya Pradesh, South Rajasthan, and parts of Deccan (Blatter and Mc Cann, 1935)
Mysore (black soil, semiarid region)	*Pennisetum pedicellatum*	6 800 (hay)	(Krishnamurthi, 1958)
	Chrysopogon fulvus	5 250	
Punjab, Ambala, Siwalik region	*Eulaliopsis binata*	—	
Uttar Pradesh (alluvial soil, humid tropical valley climate)	*Chrysopogon fulvus*	19 170	Perennial legume provides excellent cover before monsoon; very aggressive
	Eulaliopsis binata	16 290	
	Pueraria hirsuta	11 200 to 18 725	
Lesser Himalayas (Mathur et al., 1969)	*Pennisetum Purpureum*	—	Up to an elevation of 1 500 m
	Apluda mutica	—	do
	Heteropogon contortus	—	do
	Chrysopogon fulvus		do
	Eriophorum comosum	—	do
(Dabadghao, 1964)	*Chrysopogon fulvus*	—	1 500 to 2 600 m
	Themeda anather (northern slopes	—	
	Arundinella	—	
	nepalensis (warmer slopes), Pennisetum orientale	—	Comes up on road-side cuts
Tamil Nadu (Madhavrao et al., 1968)	*Trifoliumrepens*	—	High rainfall, high elevation
	T. repens var Dadino	—	100 m and above
	T. incarnatum	—	
	T. subterraneum		
	T. dubium	—	Good pasture plants
	Vicia villosa	—	All legumes
	V. angustifolia	—	
	V. sativa	—	
	Clitoria ternatea		Legume for dry areas
	Glycine javanica		Legume for high rainfall, warm climate
	Pennisetum clandestinum (kikiyu grass)	12 500	Very good for covering steep unstable areas, forms a good cover but may run wild

ANNEX B

(*Clause* 4.3)

LIST OF TRIALS AND THEIR RESULTS

Application Area	*Material Supplied & Quantity*	*Site & User*	*Date of Application*	*Result*
1. Mine spot stabilisation	6.5 × 4.5, — 500 g/m², 10 000 m²	Sahashradhara, Uttar Pradesh, Central Soil & Water Conservation Research & Training Institute	1987 Supplied by Ludlow	By 1990 erosion checked and water pollution decreased
2. Hill slope protection	do 5 000 m² each	Chunabhati & Kalijhora, Darjeeling, Deptt. of Forest, Govt of West Bengal	1988 Supplied by Ludlow	Treated areas observed double vegetation density over the untreated areas after 6 months
3. Sand dune stabilization	6.5 × 4.5 — 500 g/m², 5 000 m²	Digha Sea Beach Midnapore, Forest Deptt., Govt. of W. B.	1988 Supplied by Ludlow	80% covered by vegetation after 6 months
4. Control of top soil erosion	34 × 15 — 400 g/m², 5 000 m² and 17 × 4.5 — 300 g/m², 5 000 m²	Arcuttipur, T. E. Cachar, Assam, TRA do	July 95 Supplied by Hastings do	97% reduction in soil loss 93% reduction in soil loss
5. do	34 × 15, — 425 g/m²	Rosekandy TC Cachar, Assam, TRA	July 95 Supplied by Gloster	95% reduction in soil loss
6. Erosion control in embankment	6.5 × 4.5 — 425 g/m², 3 000 m²	Valuka, Maldah Irrigation Deptt. Govt. of West Bengal	August 96 Supplied by Gloster	No damage by rains in 96 & 97
7. Sand dune stabilisation	34 × 15 — 400 g/m², 1 000 m²	Digha Sea Beach, Midnapore, Forest Deptt., Govt. of W. B.	Aug 97 Supplied by Hastings	Washed away by high tide in Sept 97
8. Land slide repair	6.5 × 4.5 — 500 g/m², 5 000 m²	Kaliasour, U. P. CRRI & PWD of U. P. Govt	1996 Supplied by Gloster	60% vegetation observed in 1997
9. Road side slope protection	do	Ponta Sahib Himachal Pradesh, CRRI & P. W. D. Govt. of H.P.	1997	Under observation Supplied by Gloster
10. Afforestation & erosion control	34 × 15 — 25g/m², 1 000 m² each & 11 × 12.300 g/m² — 1 000 m² each	Hijli & Porapara, Midnapore Forest Deptt. Govt. of W. B.	Aug 97 Supplied by Hastings	Growth of the trees in the treated area significantly higher. No sign of erosion
11. Hill slope protection	6.5 × 4 — 500 g/m², 4000 m²	Lamding, Assam Chief Engineer, N. F. Rly Assam	Aug 97 Supplied by Gloster	Under investigation by users

ANNEX C

(Foreword)

COMMITTEE COMPOSITION

Geosynthetics Sectional Committee, WRD 25

Organization	*Representative (s)*
Indian Institute of Technology, New Delhi	PROF G. V. RAO ***(Chairman)***
Associated Instruments Manufacturers (India) Pvt Ltd, New Delhi	SHRI A. C. BAVEJA
Aspinwal Geotech, Cochin	SHRI E. B. UNNI SHRI SHIVARANAKRISHNASWAMY (*Alternate*)
Bombay Textile Research Association, Mumbai	SHRI A. N. DESAI SHRI V. K. PATIL (*Alternate*)
Calcutta Port Trust, Kolkata	SHRI T. SANYAL
Central Water Commission, New Delhi	DIRECTOR (EMBANKMENT AND DESIGN — N&W) DIRECTOR (BC & N&W) (*Alternate*)
Coir Board, Cochin, Kerala	SHRI CHRISTY FERNANDEZ SHRI M. KUMARASWAMY PILLAI (*Alternate*)
Central Board of Irrigation & Power, New Delhi	SHRI A. R. G. RAO
CE (AF) Shillong Zone, Shillong	SHRI G. C. MISHRA
Central Building Research Institute (CSIR), Roorkee	DR K. G. GARG
Central Soil & Materials Research Station, New Delhi	DR K. VANKATACHALAM SHRI S. K. BABBAR (*Alternate*)
Department of Road & Building, Govt of Andhra Pradesh, Hyderabad	SHRI JASWANT SINGH
Gujarat Engineering Research Institute, Vadodara	SHRI V. S. BRAHMBHATT SHRI H. P. PANDYA (*Alternate*)
Global Environmental Geotechnology, New Delhi	SHRI S. S. SARKAR
Howe (India) Private Ltd, New Delhi	SHRI C. S. DEBKE
Indian Institute of Technology, New Delhi	PROF P. K. BANERJEE DR K. K. GUPTA (*Alternate*)
Indian Jute Research Association, Kolkata	DIRECTOR
Indian Institute of Science, Bangalore	PROF A. SRIDHARAN
Maharashtra Engineering Research Institute, Nasik	DIRECTOR
Ministry of Surface Transport, New Delhi	SHRI C. C. BHATTACHARYA SHRI A. P. S. SETHI (*Alternate*)
Netlon India, Vadodara	DR JIMMY THOMAS
Port Blair; Andaman & Nicobar Island	EXECUTIVE ENGINEER
Public Works Department, Lucknow	DR G. P. S. CHAUHAN
Water & Power Consultancy Services (India) Ltd, New Delhi	SHRI INDER MOHAN
Research Design & Standards Organization, Lucknow	JOINT DIRECTOR RESEARCH (GS) ASSTT RESEARCH ENGINEER GEII (*Alternate*)
In Personal Capacity (*RH-4, X-1 Sector, CBD, Konkan Bhavan, New Mumbai-400614*)	PROF R. K. KATTI
In Personal Capacity (*HUDA Residental Complex, Hyderabad*)	SHRI K. R. SAXENA
In Personal Capacity (*Rahim Mansion, Building No. 2, 1st Floor, 44 Shahed Bhagat Singh Road, Mumbai 400039*)	SHRI K. R. DATYE
BIS Directorate General	SHRI S. S. SETHI, Director & Head (WRD) [Representing Director General *(Ex-officio Member)*]

Member Secretary
SHRI R. S. JUNEJA
Joint Director (WRD), BIS

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of stardardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc: No. **WRD 25 (290).**

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 323 01 31, 323 3375, 323 94 02

Telegrams: Manaksanstha
(Common to all offices)

Regional Offices:		Telephone
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	323 76 17, 323 38 41
Eastern	: 1/14 C.I.T. Scheme VII M, V.I.P. Road, Kankurgachi CALCUTTA 700054	337 84 99, 337 85 61 337 86 26, 337 91 20
Northern	: SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43 60 20 25
Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	254 12 16, 254 14 42 254 25 19, 254 13 15
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	832 92 95, 832 78 58 832 78 91, 832 78 92
Branches	: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. NALAGARH, PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM.	

Printed at Simco Printing Press, Delhi