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BUREAU OF INDIAN STANDARDS
(NEW DELHI)

AGENDA

GEO-SYNTHETICS SECTIONAL COMMITTEE, TXD 30 — **32nd Meeting**

Date/Day	Time	Venue
08 November, 2024 (Friday)	1100 h	Through Video Conferencing

Chairman: Dr. A. N. Desai, SITRA Council, Coimbatore

Member Secretary: Shri Himanshu Shukla, Scientist-B, Textile Department

ITEM 0 WELCOME AND INTRODUCTORY REMARKS BY THE CHAIRMAN

ITEM 1 CONFIRMATION OF MINUTES OF LAST MEETINGS

2.1 The minutes of the 31st meeting of TXD 30 held on 09 August, 2024 were circulated vide letter No. TXD 30/A2.31 dated 31 August 2024. No comments have been received.

2.1.1 The committee may **CONFIRM** the minutes as circulated.

Item 3 SCOPE AND COMPOSITION OF TXD 30

3.1 The present scope and composition of TXD 30 is given in **Annex 1** (**P- 05 to 07).**

3.1.1 The committee may **REVIEW**.

3.2 Co-option requests have been received from Dr. Anand Hulagabali, Terre Armee India Pvt. Ltd., New Delhi, Dr. Deepak Manjunath, Terre Armee India Pvt. Ltd., New Delhi and M/s Shahi Garg, Ventara Hi-Tech fabric. The cooption mails, CVs and other details as received are given in **Annex 2 (P- 08 to 42)**.

3.2.1 The committee may **NOTE** and **DECIDE**.

ITEM 4 ISSUES ARISING OUT OF THE PREVIOUS MEETING

4.1 A summary of actions on the various decisions taken during the 31st meeting is given in **Annex 3 (P-43 to 46).**

4.1.1 The committee may **NOTE**.

ITEM 5 DRAFT STANDARDS FOR FINALIZATION

5.1 As decided by the committee in the last meeting, the draft standard on 'Textiles — Coir Non-Woven Stitched Composite Geotextiles for Erosion Control Applications — Specification [Doc. No. TXD 30 (25914)]' was issued in wide circulation for two months for eliciting technical comments from stakeholders, dated 22 June 2024 with the last date of comment on 19 August 2024.

Draft standard as issued in wide circulation is given in **Annex 4 (P- 47 to 63)**

Comments have been received from Shri Pradip Kumar Choudhary, In Personal Capacity and are given in **Annex 5 (P - 38 to 40).**

5.1.1 The committee may **DELIBERATE** and **DECIDE.**

5.2 As decided by the committee in the last meeting, the following draft standards was issued in wide circulation for one month for eliciting technical comments from stake holders vide our letter reference no.- TXD 30/25914 dated 17 September 2024 with the last date of comment on 16 October 2024.

i) Geotextiles and geotextile — related products - Strength of internal structural junctions (Part 2) : Geo-composites (first revision) [Doc. No. TXD 30 (26515)].
ii) Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement [Doc. No. TXD 30 (26517)].
iii) Geotextiles and geotextile-related products — Screening test methods for determining the resistance to acid and alkaline liquids (first revision) [Doc. No. TXD 30 (26519)].
iv) Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 1: Index test (first revision) [Doc. No. TXD 30 (26520)].
v) Geotextiles and Geotextile-related Products — Determination of Water Flow Capacity in their Plane Part 2: Performance Test [Doc. No. TXD 30 (26521)].

Draft standards as issued in wide circulation are given in **Annex 6 (P- 65 to 94).** No comments were received.

5.2.1 The committee may **DECIDE.**

ITEM 6 COMMENTS ON INDIAN STADNARDS

6.1 Comments have been received from Shri Soumendra Banerjee, Terre Armee, New Delhi on IS 17373 : 2020 'Geosynthetics — Geogrids Used in Reinforced Soil Retaining Structures — Specification'. The comments as received, are given in **Annex 7 (P- 95 to 97).**

6.1.1 The committee may **DELIBERATE** and **DECIDE.**

6.2 Comments have been from Shri Ashish Mohan, RMG Polyvinyl India Limited on IS 15909 : 2020 'PVC Geomembranes for Lining — Specification'. The comments as received, are given in **Annex 8 (P- 98 to 161).**

6.2.1 The committee may **DELIBERATE** and **DECIDE.**

6.3 Comments have been received from Shri Aanand Jain, Green Infrastructures Systems Pvt. Ltd., Mumbai on IS 18591 : 2024 'Geosynthetics Reinforced Soil Structures — Code of Practice'. The comments as received are given in **Annex 9 (P- 162 to 163).**

6.3.1 The committee may **DELIBERATE** and **DECIDE.**

6.4 A query has been received from Shri Vijendar Rao, Maccaferri Environmental Solutions Pvt. Ltd. related to IS 16392 : 2015 'Geosynthetics - Geotextiles for permanent erosion control in hard armor systems – Specification'.

The mail and the details as received from Maccaferri Environmental Solutions Pvt. Ltd. are given in **Annex 10 (P-164 to 178).**

6.4.1 The committee may **DELIBERATE** and **DECIDE.**

ITEM 7 REVIEW OF STANDARDS

7.1 In 29th meeting of TXD 30, it was decided that IS 16090 : 2013 'Geotextiles Used as Protection (or Cushioning) Material' will be reviewed in light of advancements in technology, current industrial practices, and the evolving expectations of consumers and users. The standard was circulated to all members for seeking comments on the standard.

Comments have been received from Shri Ratnakar Mahajan, Maccaferri Environmental Solutions Private Limited, Gurugram, Shri Rajendra Ghadge, Garware Technical Fibers, Pune and Shri V. N. Gore, In personal capacity, Smt. Soumita Chowdhury, IJIRA, Kolkata. Comments as received are given in **Annex 11 (P- 179 to 183).**

7.1.1 The committee may **DELIBERATE** and **DECIDE.**

ITEM 8 INTERNATIONAL ACTIVITIES

8.1 A meeting of ISO/TC 221 'Geosynthetics' and ISO TC/221/WG 6 'Design Using Geosynthetics' is being held on 19th November 2024 in hybrid mode. Agenda and relevant meeting documents circulated by ISO TC 221 are enclosed at **Annex 12** (Attached separately).

8.1.1 The committee may **NOTE** and **DECIDE.**

8.2 A ballot was received on new work item proposal, ISO/NP TS 25332 'Geosynthetic Cementitious Mats (GCCMs) and Barriers (GCCBs)' from ISO TC 221 'Geosynthetics' from ISO/TC 221 'Geosynthetics'. The ballot was circulated via IRD portal for seeking the comments and call for expert.

The new work item proposal alongwith the draft as received from ISO TC/221 are given in **Annex 13 (P- 184 to 186)**.

Following experts were nominated with the approval of the Chairperson, TXD 30, to actively participate and provide their inputs during the development of the document:

a) Shri Saurabh Vyas, Techfab India Pvt. Ltd., Mumbai
b) Shri Suraj Vedpathak, Strata Geosystems Pvt. Ltd., Mumbai

8.2.1 The committee may **NOTE.**

8.3 A new IRD portal has been developed by BIS for circulation and commenting on ISO ballots, managing meetings. The user manual for accessing and commenting the IRD portal is given at **Annex 14** (Attached separately).

8.3.1 The committee may **NOTE.**

ITEM 9 ANY OTHER BUSINESS

ANNEX 1
(*Item* 2.1)

SCOPE AND COMPOSITION OF GEOSYNTHETICS SECTIONAL COMMITTEE, TXD 30

SCOPE: a) To formulate Indian standards on terminology, testing, specifications and codes of practices for identification, handling, storage and installation, etc. of all geo-synthetic products including geo-textiles, geo-membranes, geo-grids, geo-foams, geo-composites, clay liners and other geo-synthetic related products.

b) To liaise with the work of ISO/TC 221 Geo-synthetics Technical Committee as a participating member.

Meeting(s) held	**Date & Place**
29th Meeting	20 July 2023 Videoconferencing
30th Meeting	28 Dec 2023 Videoconferencing
31th Meeting	09 Aug 2024, Videoconferencing

Sl No.	*Organization*	*Representative(s)*	*Attendance*
1.	The South India Textile Research Association Council, Coimbatore	Dr A. N. Desai (***Chairman***)	3/3
2.	Ahmedabad Textile Industry's Research Association, Ahmedabad	Smt Deepali Plawat Shri Jigar Dave (*Alternate*)	2/3
3.	Andhra University, Visakhapatnam	Prof. K Rajagopal	2/2
4.	Best Geotechnique Pvt Ltd, Mumbai	Shri Satish Naik	3/3
5.	Central Coir Research Institute, Alappuzha	Dr. Shanmugasundaram O.L. Smt Sumy Sebastian (*Alternate*)	3/3
6.	Central Road Research Institute, New Delhi	Dr. P. S. Prasad Dr. Parvati G. S (*Alternate*)	2/3
7.	Central Soil and Materials	Dr R. Chitra	3/3

	Research Station New Delhi	Dr Manish Gupta (*Alternate*)	
8.	Central Water Commission, New Delhi	Shri Somesh Kumar Shri Kayum Mohammad (*Alternate*)	0/0
9.	Charankattu Coir Mfg. Co. (P) Ltd, Kerala	Shri C. R. Devraj Shri C. D. Athul Raj (*Alternate*)	3/3
10.	Department of Jute and Fibre Technology, Kolkata	Dr Swapan Ghosh Dr A. K. Singho (*Alternate*)	2/3
11.	DKTE Centre of Excellence in Nonwovens, Ichalkaranji	Dr. Shirish Kumar Vhanbatte	2/3
12.	Ganga Flood Control Commission, Patna	Shri S. K. Rajan Shri N. N. Shankar (*Alternate*)	2/3
13.	Garware Technical Fibers Ltd, Pune	Shri Tirumal Kulkarni Shri Rajendra Ghadge (*Alternate*)	3/3
14.	Geosynthetics Testing Services Pvt Ltd, Ahmedabad	Shri Ravikant Sharma	3/3
15.	ICAR- National Institute of Natural Fibre Engineering & Technology, Kolkata	Dr. Sanjoy Debnath Dr. Kartick Samanta (*Alternate)*	3/3
16.	Indian Geotechnical Society, New Delhi	Dr. Bappaditya Manna Dr Debayan Bhattacharya(Alternate)	1/3
17.	Indian Institute of Technology, Gandhinagar	Prof. Amit Prashant Dr. G V Rao (*Alternate*)	2/3
18.	Indian Institute of Technology, Madras	Prof. Dalli Naidu Arnepalli	1/3
19.	Indian Jute Industries' Research Association, Kolkata	Smt. Soumita Chowdhury Shri Partha Sanyal (*Alternate*)	2/3
20.	Indian Jute Mills Association, Kolkatta	Shri S. K. Chandra Shri J. K. Behera (*Alternate*) Shri Bhudipta Saha (YP)	2/3
21.	Indian Technical Textile Association, Mumbai	Dr. Anup Rakshit Smt. Ruchita Gupta (*Alternate*)	2/3
22.	International Geosynthetics Society, India Chapter, New Delhi	Prof. G. L Sivakumar Babu Smt. Dola Roychowdhury (*Alternate)*	1/3
23.	Kusumgar Corporates, Mumbai	Shri Y. K. Kusumgar Dr M. K. Talukdar (*Alternate*)	2/3
24.	Landmark Material Testing	Dr. Anil Dixit	3/3

	and Research Laboratory Pvt. Ltd, Jaipur	Shri Harsh Kumar Chittora (*Alternate*)	
25.	Macaferri Environmental Solutions Pvt Ltd, Navi Mumbai	Dr. Ratnakar Mahajan Smt Minimol Korulla (*Alternate*)	3/3
26.	National Jute Board, Kolkatta	Shri M. Dutta	3/3
27.	Office of The Jute Commissioner, Kolkata	Shri Soumyadipta Datta	2/3
28.	Office of the Textile Commissioner, Mumbai	Shri Sivakumar S Shri Sanjay Charak (*Alternate*)	2/3
29.	Premier Polyfilms Ltd, Ghaziabad	Shri Amitaabh Goenka Shri Praveen Kumar (*Alternate*)	2/3
30.	Rajadhani Institute of Engineering & Technology, Trivandrum	Dr. K. Balan	2/3
31.	RDSO, Lucknow	Shri Sanjay Kumar Awasthi Shri Santosh Kumar Ojha (*Alternate*)	3/3
32.	Reliance Industries Ltd, New Delhi	Shri Vinod Kumar R. Shri Chetan Patil	3/3
33.	Sahastra Engineers Pvt Ltd, Noida	Shri Vankata Mayur	2/3
34.	Strata Geosystems (I) Pvt Ltd, Mumbai	Shri Narendra Dalmia Shri Shahrokh Bagli (*Alternate*) Shri Suraj Vedpathak (YP)	3/3
35.	Techfab India, Mumbai	Shri Anant Kanoi Shri Saurabh Vyas (*Alternate*)	3/3
36.	The Bombay Textile Research Association, Mumbai	Dr. Sreekumar Dr. Prasanta Kumar Panda (*Alternate*)	3/3
37.	The Synthetics & Art Silk Mills Research, Association, Mumbai	Dr. Manisha Mathur Smt. Ashwini Sudam (*Alternate*)	3/3
38.	In Personal Capacity	Shri V. N. Gore	1/3
39.	In Personal Capacity	Shri P. K. Choudhury	3/3

ANNEX 2
(*Item* 3.2)

CO-OPTION REQUEST FROM TERRE ARMEE, NEW DELHI

a) CO-OPTION REQUEST FROM TERRE ARMEE, NEW DELHI

I) Details of Dr. Anand Hulagabali

Member Details

1. Invite Id	3925996276
2. Name	Anand Hulagabali
3. Email ID	anandmhulagabali@gmail.com
4. Alternate Email	anand.hulagabali@vinci-construction.com
5. Mobile Number	8050611303
6. Address	E-11, B-1 Extension, NH-19, Block B-1, Block E, Mohan Cooperative Industrial Estate, Badarpur, Delhi 110044, New Delhi, DELHI, India
7. Organization Name	Terre Armee India, New Delhi
8. Designation	Manager - Specification Engineering
9. Other Relevant Information Dr.	Anand Hulagabali did his Ph.D. and M.Tech. in Geotechnical Engineering from SVNIT Surat, Gujarat. His areas of expert are Reinforced Earth Structures and Geosynthetics. He has 9 years of work experience in academics. He has published around 50 research papers. He has been granted four patents and guided 28 M.Tech. students.
10. Download Cv Docs	

11. Organization Authorization Letter

Educational Qualification :

S No	Degree	Institute Name	Passing year
1	Graduate	VTU Belagavi Karnataka	2011
2	Post Graduate	SVNIT Surat	2014
3	Doctorate	SVNIT Surat	2021

Experience of R & D projects undertaken :

S No	Project Name	Institute Name	Research File
1	NA	NA	

Papers Published(Not more than 3 important ones) :

S No	Title	Publisher	Year	File
1	Seismic Internal Stability Analysis of Modular Block Reinforced Earth Retaining Wall	International Journal of Geosynthetics and Ground Engineering, Springer	2023	
2	Finite Element Analysis of Segmental Precast Panel Reinforced Earth Retaining Wall	Jordan Journal of Civil Engineering	2023	
3	Numerical analysis of pile group, piled raft , and footing using finite element software PLAXIS 2D and GEO5	Scientific Reports, Nature	2023	

Applied in following departments :

S No	Technical Department	Technical Commiittee	Status
1	Civil Engineering Department (CED	Hill Area Development Engineering (56)	Pending
2	Textiles Department (TXD)	Geosynthetics (30)	Pending
3	Civil Engineering Department (CED)	Soil And Foundation Engineering (43)	Pending
4	Civil Engineering Department (CED)	Earthquake Engineering (39)	Pending
5	Civil Engineering Department (CED)	()	Pending
6	Civil Engineering Department (CED)	()	Pending
7	Civil Engineering Department (CED)	Electronic Measuring Instruments, Systems And Accessories (8)	Pending

DR. ANAND HULAGABALI - Brief CV

Basic Information			
1	Name and Address	Dr. Anand Hulagabali Phone: 8050611303 Email ID: anandmhulagabali@gmail.com	
2	Nationality / Age / Date of Birth	Indian / 35 / 05.08.1989	
3	Prior Degrees / Year / University	**Ph. D. (Geotech) / 2021 / NIT Surat** **M.Tech. (Geotech) / 2014 / NIT Surat** **B. E. (Civil) / 2011 / VTU Belgaum**	
Teaching			
4	Experience (in years) Teaching Experience	UG & PG: **9 Years**	
5	Courses Taught	UG	PG
		5	12
6	Performance in Teaching (Only NIE)	Students Rating	Pass Percentage
		> 95%	> 95%
Research			
7	Research Guidance (Numbers)	Completed	
		M.Tech.	
		28	
8	Publication Details (Numbers)		

	• Journal Papers	**7 (SCI = 5; SCOPUS = 2)**
	• Conference Papers	**32**
	• Book Chapters	**12 (Scopus Indexed Chapters)**
9	Books	3
Consultancy		
10	Consultancy	More than 500 works worth more than **Rs. 75,00,000**
Innovation		
11	Patents	Granted
		4
Interaction with outside world		
12	Conferences/STTP/Seminars/Webinars attended (Numbers)	80
13	Invited expert talks delivered (Numbers)	21
14	Memberships in Professional Bodies (Numbers)	9
Personal Website		www.dranandmh.co.in

DR. ANAND HULAGABALI - Detailed CV
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BRIEF INTRODUCTION

Presently, I am working as “Manager, Specification Engineering at Terre Armee India”. I have vast 9 years of experience in the teaching, research, and consultancy. I completed my bachelor’s degree in civil engineering from KLES College of Engineering in Belgaum. My M.Tech. and Ph.D. were obtained from NIT Surat, Gujarat in Geotechnical Engineering. My primary research interests encompass reinforced earth structures and geosynthetics, ground improvement techniques, computational geomechanics, and deep foundations.

As part of my M.Tech. and PhD studies, I gained valuable research experience at IIT Madras under the guidance of Dr. G. R. Dodagoudar. I worked at Basaveshwar Engineering College, Bagalkot from 2015 to 2017. Following that, I spent around 3 years (From 2017 to 2020) at Ambo University in Ethiopia, Africa, as part of the UNDP program. During my time in Ethiopia, I also served as a visiting faculty member at esteemed universities such as Jimma University, Arba Minch University, Dire Dawa University, and Hawassa University. I worked at Department of Civil Engineering, The National Institute of Engineering, Mysuru from 2020 to 2024.

At NIE Mysuru, in addition to my research and teaching responsibilities, i was actively engaged in geotechnical engineering consultancy work for both state and central government infrastructure projects. I provided my expertise to various departments, including CBI, RBI, NHAI, AAI, Indian Railways, CPWD, MUDA, MMC, Infrastructure Development Department, Minor Irrigation Department, Planning Department, PWD, RDPR, Revenue Department, Tourism Department, Water Resources Department, and many others. The total value of the consultancy projects I have completed amounts to Rs. 75,00,000.

I have authored three books focusing on research in the field of Geotechnical Engineering. Additionally, I have contributed to the publication around 50 research papers, encompassing book chapters, peer-reviewed journals, and conference proceedings. Recently, I have been granted four patents, highlighting my innovative contributions. Furthermore, I have provided guidance to 28 M.Tech. students in the past. Throughout my career, I have actively participated in 80 conferences, STTPs (Short-Term Training Programs), and seminars, both in India and abroad.

I have had the privilege of delivering numerous technical and motivational speeches at various engineering colleges both within India and abroad. Additionally, I actively contribute as a Reviewer and Editorial board member for five esteemed peer-reviewed journals. Furthermore,

I hold memberships in several prestigious professional organizations, including the American Society for Civil Engineers, Indian Geotechnical Society, International Society for Geosynthetics, International Society for Soil Mechanics and Geotechnical Engineering, Institute of Engineers India, and Association of Consulting Civil Engineers India.

ACADEMIC PROFILE

Ph.D. (2021) – Geotechnical Engineering (Civil Engineering)
Sardar Vallabhbhai National Institute of Technology, SVNIT, Surat (NIT Surat)
Grade: 9.67

M.Tech. (2014) – Soil Mechanics & Foundation Engineering
Sardar Vallabhbhai National Institute of Technology, SVNIT, Surat (NIT Surat)
Grade: 9.47

B.E. (2011) – Civil Engineering
KLES's M.S. Seshagiri College of Engineering & Technology, Belagavi (VTU)
Percentage: 73.44%

PROFESSIONAL EXPERIENCE

Total Experience = **9 Years**

Assistant Professor
Department of Civil Engineering,
The National Institute of Engineering, NIE Mysuru 10th March, 2020 – 1st March, 2024
Lecturer

Department of Civil Engineering, Ambo University, Ethiopia
25th October, 2017 – 9th February, 2020

Visiting Faculty
Arba Minch University, Jimma University, Dire Dawa University (Ethiopia)
15th August, 2018 – 19th November, 2019

Assistant Professor
PG Geotechnical Engineering - Civil Engineering Department, Basaveshwar Engineering College, Bagalkot
19th January 2015 - 16th September, 2017

CONSULTANCY WORK CARRIED OUT

- Design and Analysis of Reinforced Earth Retaining Wall
- Design Proof Checking of MSE Wall
- Soil Investigation Works
- Slope Protection Works
- Earthen Dam Analysis and Design
- Soil Structure Interaction (2D, 3D Finite Element Analysis)
- Design of Deep Excavation Support Scheme in Urban Areas
- Geotechnical Interpretative Reports (GIR)
- Proof Checking, Peer Review of Third-Party Designs
- Design of Shallow Foundations
- Design of Deep Foundations
- Ground Improvement Solutions
- Instrumentation and Monitoring Solutions

AWARDS

1. The paper titled "Two-dimensional finite element modelling of an underground tunnel and its impact on the settlement of neighboring structures" received the prestigious **BEST TECHNICAL PAPER AWARD** at the International Conference on Sustainable Infrastructure: Innovations, Opportunities, and Challenges-2023 (SIIOC-2023), held on April 20th and 21st, 2023, at NIT Surathkal.

2. The paper titled "Seismic Response Analysis of High-Rise Building Considering the Effect of Soil-Structure Interaction" was honored with the prestigious **BEST PAPER AWARD** at the First International Conference on Innovation in Smart and Sustainable Infrastructure, hosted by the Department of Civil Engineering, Pandit Deendayal Energy University in Gandhinagar, Gujarat. The conference took place from the 23rd to the 25th of August, 2022.

3. The paper titled "Performance Evaluation of Earthen Embankment underlain by Marine Clay Deposit with Ground Improvement Techniques - A Case Study of Mangaluru

Region, Karnataka" received recognition for being the **BEST PAPER WITH MINIMUM PLAGIARISM** at the Proceedings of Indian Geotechnical Conference held at NIT Trichy in 2021.

4. The paper titled "Assessment of Effect of Deep Excavation on Adjacent Structures using Finite Element Analysis" was honoured with the **BEST PAPER AWARD** at the Proceedings of Indian Geotechnical Conference held at Andhra University, Vishakhapatnam in 2020.

RECOGNITIONS

1. Chaired a Technical Session at Prestigious conference IGC 2023, at IIT Roorkee.

2. Honorary Secretary of Indian Geotechnical Society, Mysuru Chapter.

3. Board of Examinations (BOE) member for the following institutes;
    - CEPT University, Ahmedabad
    - Vidya Vardhak College of Engineering, Mysuru
    - JSS Technical University, Mysuru
    - VTU Belagavi
    - JNTU Ananthpuram

4. Editorial Board Member and Technical Review Member of the following journals and Conferences;
    - Reviewer of “Geomechanics and Geoengineering - An International Journal”, Taylor & Francis (SCI Indexed)
    - Reviewer of "Materials Today: Proceedings" Elsevier (Scopus Indexed)
    - Reviewer of "Recent Patents on Engineering" (Scopus Indexed)
    - Reviewer of American Journal of Civil Engineering
    - Reviewer of Advances in Science, Technology and Engineering Systems Journal (ASTESJ) (Scopus)
    - Technical Expert Committee Member of Global Virtual Conference on Disaster Risk Reduction - Civil Engineering for a Disaster Resilient Society, 19-21st March 2021 organized by ADRRN, IHRR, and NITK.
    - Member of the Technical review committee of International Conference on New Horizon in Civil Engineering (NHCE 2023) on October 13-14, 2023, at MIT, Manipal.
    - Technical Reviewer of International Conference on Interdisciplinary Approaches in Civil Engineering for Sustainable Development organised by Jyothy Institute of Technology, Bangalore; Dates: 7-8 July 2023.

PATENTS

1. Soil Permeability Test Apparatus – 363894-001 (Granted)
2. Carbonation Test System for Concrete - 3635990-001 (Granted)

3. Heat of Hydration of Concrete - 363598-001 (Granted)
4. Portable Soil Analysis Apparatus – 363850-001 (Granted)

PUBLICATIONS
SCI Indexed Journal (5)

1. **Hulagabali, A. M**., Solanki, C.H., Dodagoudar, G.R. and N. Anitha, "Seismic Internal Stability Analysis of Modular Block Reinforced Earth Retaining Wall". *International Journal of Geosynthetics and Ground Engineering*. 9, 31 (2023). https://doi.org/10.1007/s40891-023-00448-9

5. **2.** Firanboni Fituma Chimdesa, Firaol Fituma Chimdesa, Nagessa Zerihun Jilo, **Anand Hulagabali**, "Numerical analysis of pile group, piled raft, and footing using finite element PLAXIS 2D and GEO5". Scientific Reports. 13, 15875 software (2023). https://doi.org/10.1038/s41598-023-42783-x

2. **Anand. M. Hulagabali,** Anitha, G. R. Dodagoudar, C. H. Solanki, "Finite Element Analysis of Segmental Precast panel Reinforced earth retaining wall", Jordon Journal of Civil Engineering, Volume 17, No. 4 (2023). https://doi.org/10.14525/JJCE.v17i4.03

3. **A M Hulagabali**, C H Solanki, G R Dodagoudar (2019), "Internal and external stability analysis of MSE wall subjected to static and seismic conditions", Ciencia E Tecnica Vitivinicola - A Science and Technology Journal (ISSN: 2416-3953) Vol. 34, Issue. 11, pp. 78-90.

4. **A M Hulagabali,** C H Solanki, G R Dodagoudar, S S Konnur, M P Shettar (2018), "Analysis of Mechanically Stabilized Earth (MSE) Retaining Wall using Finite Element and AASHTO methods", Journal of Engineering Technology, Vol. 6, Special Issue (Emerging Technology in Engineering Technology), pp. 139150, American Association of Engineering Education.

Scopus Indexed Journal (2)

1. **Anand M Hulagabali**, C H Solanki, G R Dodagoudar, M P Shettar (2018), "Influence of Supporting Systems on Behaviour of MSE wall", International Journal of Civil Engineering and Technology, 9(4), pp. 1000-1007.

2. **A M Hulagabali**, C H Solanki, G R Dodagoudar, M P Shettar (2018), "Effect of Reinforcement, Backfill and Surcharge on the Performance of Reinforced Earth Retaining Wall", ARPN Journal of Engineering and Applied Science, Vol. 13, No. 9, pp. 3324-3230, Asian Research Publication Network.

Scopus Indexed Book Chapters (10)

1. **Hulagabali, A.M.,** Solanki, C.H., Thrupthi, C., Sushma, N., Suokhrie, R., Sudarshan, S. (2024). Pull-Out and Rupture Behavior of Geogrid Reinforcements in MSE Wall Subjected to Seismic Conditions. In: Patel, D., Kim, B., Han, D. (eds) Innovation in Smart and Sustainable Infrastructure. ISSI 2022. Lecture Notes in Civil Engineering, vol 364. Springer, Singapore. https://doi.org/10.1007/978-981-99-3557-4_19

2. **Hulagabali, A. M.,** Solanki, C.H., Dodagoudar, G.R. (2023). Study on Soil–Panel Interaction on the Performance of MSE Wall. Earth Retaining Structures and Stability Analysis. IGC 2021. Lecture Notes in Civil Engineering, vol 303. Springer, Singapore. https://doi.org/10.1007/978-981-19-7245-4_39

3. **Hulagabali, A. M.,** Srujana, R., Rachana, A.V., Longkumer, M.Y. (2023). Numerical Analysis of Earthen Embankment Resting on Soft Clay Deposit. Earth Retaining Structures and Stability Analysis. IGC 2021. Lecture Notes in Civil Engineering, vol 303. Springer, Singapore. https://doi.org/10.1007/978-981-19-7245-4_38

4. **Hulagabali, A. M**., Srujana, R., Rachana, A.V., Longkumer, M.Y. (2023). Performance Evaluation of Earthen Embankment Underlain by Marine Clay Deposit with Ground Improvement Techniques—A Case Study of Mangaluru Region, Karnataka. Ground Improvement Techniques. IGC 2021. Lecture Notes in Civil Engineering, vol 297. Springer, Singapore. https://doi.org/10.1007/978-981-19-6727-6_8

5. **Hulagabali, A. M**., Shilpa, V., Shobharani, N.C., Vasundhara, G.S., Prashanth, M.L. (2023). Parametric and Stability Analysis of Landslide Near Somwarpet, Coorg District, Karnataka. Earth Retaining Structures and Stability Analysis. IGC 2021. Lecture Notes in Civil Engineering, vol 303. Springer, Singapore. https://doi.org/10.1007/978-981-19-7245- 4_22

6. **Hulagabali A. M., Bariker P**., Solanki C.H., Dodagoudar G.R. (2022) Numerical Simulation of Field Vane Shear Test Using Finite Element Method. In: Satyanarayana Reddy C.N.V., Krishna A.M., Satyam N. (eds) Dynamics of Soil and Modelling of Geotechnical Problems. Lecture Notes in Civil Engineering, vol 186. Springer, Singapore. https://doi.org/10.1007/978-981- 16-5605-7_9

7. **Hulagabali A.M., Bariker P.,** Solanki C.H., Dodagoudar G.R. (2022) Assessment of Effect of Deep Excavation on Adjacent Structures Using Finite Element Analysis. In: Satyanarayana Reddy C.N.V., Muthukkumaran K., Vaidya R. (eds) Stability of Slopes and Underground Excavations. Lecture Notes in Civil Engineering, vol 185. Springer, Singapore. https://doi.org/10.1007/978-981-16-5601-9_25
8. Bariker P., Kori A., **Hulagabali A. M.** (2021) Analysis of Strength Properties of Cement-Stabilized Soil at Different Moulding Water Contents. In: Patel S., Solanki C.H., Reddy K.R., Shukla S.K. (eds) Proceedings of the Indian Geotechnical Conference 2019. Lecture Notes in Civil Engineering, vol 138. Springer, Singapore. https://doi.org/10.1007/978-981- 33-6564- 3_2

9. Badaradinni B.M., **Hulagabali A. M**., Solanki C.H., Dodagoudar G.R. (2019) Experimental Study of Heave Control Technique for Expansive Soil Using Micropiles and Geotextile Layers. In: Thyagaraj T. (eds) Ground Improvement Techniques and Geosynthetics. Lecture Notes in Civil Engineering, vol 14. Springer, Singapore.https://doi.org/10.1007/978-981-13- 0559- 7_5

10. Amashi A.R., **Hulagabali A. M.,** Solanki C.H., Dodagoudar G.R. (2019) Landslide Risk Assessment and Mitigation-A Case Study. In: Adimoolam B., Banerjee S. (eds) Soil Dynamics and Earthquake Geotechnical Engineering. Lecture Notes in Civil Engineering, vol 15. Springer, Singapore. https://doi.org/10.1007/978-981-13-0562-7_27

11. Konnur S.S., **Hulagabali A. M**., Solanki C.H., Dodagoudar G.R. (2019) Numerical Analysis of MSE Wall Using Finite Element and Limit Equilibrium Methods. In: Adimoolam B., Banerjee S. (eds) Soil Dynamics and Earthquake Geotechnical Engineering. Lecture Notes in Civil Engineering, vol 15. Springer, Singapore. https://doi.org/10.1007/978-981-13-0562- 7_22

Books Published (3)

1. **A. M. Hulagabali**, C. H. Solanki, G. R. Dodagoudar (2014), Contaminant Transport Modelling Through Saturated Porous Media using Finite Element and Finite Difference Methods, Lambert Academic Publications, Germany, ISBN: 978-3-659-52607-7.

2. **A. M. Hulagabali** (2013), Response of Tunnels subjected to Seismic Conditions, Lambert Academic Publications, Germany, ISBN: 978-3-659-52106-5.

3. Hulagabali M, Prabhakara R, A. M. Hulagabali (2018), Durability Evaluation of High-Performance Concrete, Lambert Academic Publications, Germany, ISBN: 978-6-139-84132- 5.

Conference Proceedings (33)

1. **Anand. M. Hulagabali,** Pooja. P. K., Annanya Maria, Manjula. R., Keerthana. H. V., and Anitha, "Proportioning the Backfill Soil as per IRC Specifications for the Reinforced Earth Retaining Wall", Indian Geotechnical Conference, 2023, IIT Roorkee.

2. **Anand. M. Hulagabali**, Sushank B L, Deekshitha B E, V S Shreyas and Samarth M, "Numerical Study on Effect of Excavation Depth, Slope Angle and Ground Water on the Performance of Deep Excavation", Indian Geotechnical Conference, 2023, IIT Roorkee.

3. **Anand. M. Hulagabali**, Dhariyappa Dhoolappanavar, Vadiraj Rao N R, G R Dodagoudar, Anitha Nayak and Gagana P, "Wind and Time History Analysis of Tall Reinforced Concrete Chimney Considering the effect of Soil- Foundation-Structure Interaction", Indian Geotechnical Conference, 2023, IIT Roorkee.

4. Basavaraj C S, **Anand. M. Hulagabali**, G R Dodagoudar, and Anitha Nayak, "Performance evaluation of onshore wind turbine under various support conditions considering the effect of soil- foundation structure interaction", Indian Geotechnical Conference, 2023, IIT Roorkee.

5. **Anand M Hulagabali**, Shruthi A N, Mahadeva Prasad C M, Sneha B M, A Mahanthesh, Nandan Gowda S L, "Two-dimensional finite element modelling of underground tunnel and its effects on settlement of adjacent structures", International Conference on Sustainable Infrastructure: Innovations, Opportunities and Challenges-2023 (SIIOC-2023), April 20th & 21st, 2023, NIT Surathkal. (Best Paper Award)

6. Dhariyappa S D, Vadiraj Rao N R, **Anand M Hulagabali**, G R Dodagoudar, "Wind Analysis of Tall Reinforced Concrete Chimney considering the effect of Soil-Structure Interaction", International Conference on Sustainable Infrastructure: Innovations, Opportunities and Challenges-2023 (SIIOC-2023), April 20th & 21st, 2023, NIT Surathkal.

7. Basavaraj C S, **Anand M Hulagabali**, G R Dodagoudar, "Dynamic Analysis of On-shore Wind Turbine considering the effect of Soil-Structure Interaction", International Conference on Sustainable Infrastructure: Innovations, Opportunities and Challenges-2023 (SIIOC-2023), April 20th & 21st, 2023, NIT Surathkal.

8. **Anand M Hulagabali**, Sushank B L, Deekshitha B E, V S Shreyas, Samarth M, "Settlement of adjacent structures due to nearby deep excavations- a numerical investigation", International Conference on Sustainable Infrastructure: Innovations, Opportunities and Challenges-2023 (SIIOC-2023), April 20th & 21st, 2023, NIT Surathkal.

9. Anitha, **Anand. M. Hulagabali**, C. H. Solanki, G. R. Dodagoudar, "Seismic Response Analysis of High-Rise Building Considering the Effect of Soil-structure Interaction", First International Conference Innovation in Smart and Sustainable Infrastructure, Department of Civil Engineering, Pandit Deendayal Energy University, Gandhinagar, Gujarat, 23rd to 25th August, 2022. **(Best Paper Award)**

10. Anitha, **Anand. M. Hulagabali**, C. H. Solanki, G. R. Dodagoudar, "Response Spectrum Analysis of High-rise Reinforced Concrete Framed Structure Resting on Raft and Pile Foundation System", First International Conference Innovation in Smart and Sustainable Infrastructure, Department of Civil Engineering, Pandit Deendayal Energy University, Gandhinagar, Gujarat, 23rd to 25th August, 2022.

11. **Anand. M. Hulagabali**, Thrupthi C, Sushma N, Ruokuolenuo S, Sudarshan S, "Pull-out and Rupture Behaviour of Geogrid Reinforcements in MSE Wall Subjected to Seismic Conditions", First International Conference Innovation in Smart and Sustainable Infrastructure, Department of Civil Engineering, Pandit Deendayal Energy University, Gandhinagar, Gujarat, 23rd to 25th August, 2022.

12. Sanjeevani Akki, Y M Manjunath, **Anand. M. Hulagabali**, Anitha, "Effect of Bracings on the Performance of High-Rise Structure Considering the Influence of Earthquake" First

International Conference Innovation in Smart and Sustainable Infrastructure, Department of Civil Engineering, Pandit Deendayal Energy University, Gandhinagar, Gujarat, 23rd to 25th August, 2022.

13. Anitha, **Anand. Hulagabali**, G. R. Dodagoudar, "Seismic Soil-Pile-Structure Interaction Studies of High-Rise RC Framed Structure Resting on Pile Groups", Indian Geotechnical Conference, 2022, Cochin, 15th to 17th December, 2022.

14. **Anand. M. Hulagabali**, Manya Harish, Shama K, Namratha K L, Bharathkumar K, "Effect of polypropelene planar reinforcement on the unconsolidated undrained behaviour of black cotton soil", Indian Geotechnical Conference, 2022, Cochin, 15th to 17th December, 2022.

15. **Anand. M. Hulagabali**, Manya Harish, Shama K, Namratha K L, Bharathkumar K, "Numerical simulation of triaxial test to study the effect of reinforcement in enhancing the shear behaviour of black cotton soil", Indian Geotechnical Conference, 2022, Cochin, 15th to 17th December, 2022.

16**. Anand. M. Hulagabali**, Thrupthi C, Sushma N, Ruokuolenuo S, Sudarshan S, "Parametric, Seismic & Static External Stability analysis of Mechanically Stabilised Earth Retaining Wall", Indian Geotechnical Conference, 2022, Cochin, 15th to 17th December, 2022.

17. **Hulagabali. A. M**, C. H. Solanki, G. R. Dodagoudar, "Study on Soil-Panel Interaction on Performance of MSE Wall", Proceedings of Indian Geotechnical Conference, NIT Trichy, 2021.

18. **Anand. M. Hulagabali**, R. Srujana, A. V. Rachana, M. Y. Longkumer, C. S. Suhas, "Numerical Analysis of Earthen Embankment Resting on Soft Clay Deposit", Proceedings of Indian Geotechnical Conference, NIT Trichy, 2021. (Best Paper Award for Minimum Plagiarism)

19. **Anand. M. Hulagabali**, R. Srujana, A. V. Rachana, M. Y. Longkumer, C. S. Suhas, "Performance Evaluation of Earthen Embankment underlain by Marine Clay Deposit with Ground Improvement Techniques – A Case Study of Mangaluru Region, Karnataka", Proceedings of Indian Geotechnical Conference, NIT Trichy, 2021.

20. **Hulagabali. A. M**, V. Shilpa, N. C. Shobharani, G. S. Vasundhara, M. L. Prashanth, "Parametric and Stability Analysis of Landslide near Somwarpet, Coorg District, Karnataka", Proceedings of Indian Geotechnical Conference, NIT Trichy, 2021.

21. **Anand M Hulagabali**, Pankaj B, D S Gothakhindi, C H Solanki, "Numerical Study on Prediction of behaviour of Braced Excavation in Heterogeneous Soil", Proceedings of Indian Geotechnical Conference, Andra University, Vishakpattanam, 2020.

22. **Anand M Hulagabali**, Pankaj B, C H Solanki, G R Dodagoudar, "Numerical Simulation of Field Vane Shear Test Using Finite Element", Proceedings of Indian Geotechnical Conference, Andra University, Vishakpattanam, 2020.

23. **Anand M Hulagabali**, Pankaj B, C H Solanki, G R Dodagoudar, "Assessment of Effect of Deep Excavation on Adjacent Structures using Finite Element Analysis", Proceedings of Indian Geotechnical Conference, Andhra University, Vishakpattanam, 2020. (Springer Best Paper Award)

24. Pankaj Bariker, Amrutha Kori, **Anand M Hulagabali**, "Analysis of Strength Properties of Cement Stabilized Soil at Different Moulding Water Contents", Proceedings of Indian Geotechnical Conference, SVNIT, Surat, 2019.

25. Amrutha Kori, Pankaj Bariker, **Anand M Hulagabali**, "Application of Geotextile in Ground Improvement Technique: An Over View ", Proceedings of Indian Geotechnical Conference, SVNIT, Surat, 2019.

26. Ashwini Shetty, S K Palled, **A M Hulagabali**, V A Reddy, "Experimental Investigation on viability of Metakaolin based Lead contaminated soil", Proceedings of Indian Geotechnical Conference, IIT Guwahati, 2017.

27. Akshata Aravalli, **A M Hulagabali**, C H Solanki, G R Dodagoudar, "Enhancement of index and engineering properties of expansive soil using chopped basalt fibres", Proceedings of Indian Geotechnical Conference, IIT Guwahati, 2017.

28. S S Vadavadagi, **A M Hulagabali**, G R Dodagoudar, C H Solanki," Seismic Response analysis of MSE Walls", Proceedings of Indian Geotechnical Conference, IIT Madras, 2016.

29. B M Badaradinni, **A M Hulagabali**, G R Dodagoudar, C H Solanki," Experimental Investigation of heave control technique of expansive soil using micro piles and geotextile layers", Proceedings of Indian Geotechnical Conference, IIT Madras, 2016.

30. A R Amashi**, A M Hulagabali**, G R Dodagoudar, C H Solanki, "Landslide Risk assessment and Mitigation – a case study", Proceedings of Indian Geotechnical Conference, IIT Madras, 2016.

31. S A Konnur, **A M Hulagabali**, G R Dodagoudar, C H Solanki, "Numerical and Analytical analysis of MSE wall using limit equilibrium methods", Proceedings of Indian Geotechnical Conference, IIT Madras, 2016.

32. S R Hosamani, **A M Hulagabali**, "Comparative study of stabilisation of expansive soil using Flyash, Rice husk ash, Bagasse ash and Marble dust", Proceedings on International conference on Soil and Environment, IISc Banglore, 2016.

33. **A M Hulagabali**, D R Kamde, "Biomedical waste management for Belgaum city, Karnataka, India- a case study", Proceedings of 4th International conference on Solid waste management, JNTU, Hyderabad, 2014.

Non-Indexed Journals (10)

1. Subash Thanappan, Dumessa Gudissa, **Anand M Hulagabali**, Woyesa Ararsa, Tamere Mariyam Dawit, (2020), "System Performance using Recirculating Sand filter: Proposal on sewage treatment", International Journal of Engineering Technology Research & Management, Vol 04, Issue 02, PP: 32-40.

2. **Anand Hulagabali**, K P Deepadarshan, Mahesh S, Chethan G, Kushnappa, (2020), "Analysis of landslide at Gudar-Gedo Road and proposal of mitigation measures", Iconic research and engineering journals, volume 3, issue 10, pp 136-141.

3. **Anand Hulagabali**, Dumesa Gudissa, Woyesa Ararsa (2019), "Numerical Analysis of Slope Stability- A Parametric Study", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 7 Issue I, pp. 319-324.

4. **Anand Hulagabali**, Dumesa Gudissa, Woyesa Ararsa (2019), "Analysis of Landslide near Ambo City, Ethiopia, East Africa", International Research Journal of Engineering and Technology (IRJET), Volume 6 Issue I, pp. 513-517.

5. **A M Hulagabali**, C H Solanki, G R Dodagoudar (2018), "Behaviour of MSE Wall with different Soil Properties and Reinforcement Length", International Journal for Research in Applied Science and Engineering Technology, Volume 6, Issue 1

6. Kamde D R, John B, **Hulagabali A**, (2014), "Comparative study for the design of the single span bridge using AASHTO LRFD and IS code methods", IOSR Journal of Mechanical and Civil Engineering, p. 40-44. ISSN:234X.

7. **Anand Hulagabali**, C H Solanki, G R Dodagoudar, (2014), "Migration of contaminants through a soil due to an instantaneous source", International Journal of Advanced research in Civil, Structural, Environmental and Infrastructure Engineering Development, Vol. 1, Issue.3, ISSN:2320-723X.

8. **A M Hulagabali**, C H Solanki, G R Dodagoudar, (2014), "Contaminant Transport modelling through saturated porous media using Finite element and Finite Difference methods", IOSR Journal of Mechanical and Civil Engineering, p. 29-33. ISSN: 334X.

9. **Anand Hulagabali**, C H Solanki, (2014), "3D Contaminant Transport modelling through saturated porous media using Finite Element Geotechnical package SV Office-Chemflux", International Journal of Applied Engineering Research, Vol.9, Issue.2, pp.127-132, ISSN: 0973-4562.

10. **Hulagabali A**, Kamde D, Sharanbasava P, (2013), "Three-dimensional steady state finite difference flow model- a case study", International Journal of Recent Advances in Engineering and Technology, Vol.1, Issue.3, ISSN: 2347-2812.

COURSES DELIVERED

• Fundamentals of Geotechnical Engineering (3 times) • Applied Geotechnical Engineering (3 times) • Engineering Mechanics (2 times)	*B.E Civil Engineering, NIE, Mysuru, Karnataka, India*
• Analysis and Design of Sub Structures (3 times) • Finite Element Analysis (1 time)	*M.Tech Structural Engineering, NIE, Mysuru, Karnataka, India*
• Design of Earth Retaining Structures (2 times) • Soil Exploration and Testing (2 times) • Pile Foundation Analysis and Design (2 times) • Ground Improvement Techniques (2 times) • Reinforced Earth Structure and Geosynthetics (2 times) • Environmental Geotechniques (1 time) • Geotechnical Earthquake Engineering (1 time)	*M.Tech Geotechnical Engineering, Basaveshwar Engineering College Bagalkot*
• Geotechnics for Highways (2 times) • Special Problems in Road Construction (1 time)	*M.Sc. in Highway Engineering, Ambo University, Ethiopia*
• Geotechnics for Highways (2 times) • Special Problems in Road Construction (1 time) • Advanced Pavement Design and Analysis (1 time)	*M.Sc. in Highway Engineering (Extension Program) Ambo University, Wingate Campus, Addis Ababa, Ethiopia*
• Advanced Foundation Engineering (2 times) • Advanced Computational Methods in Geotechnical Engineering (1 time) • Analysis of Slopes, Earth Retaining Structures and Underground Structures (1 time)	*M.Sc. in Geotechnical Engineering, Arba Minch University, Ethiopia*
• Advanced Foundation Engineering (2 times) • Advanced Computational Methods in Geotechnical Engineering (2 times) • Analysis of Slopes, Earth Retaining Structures and Underground Structures • Soil Dynamics and Geotechnical Earthquake Engineering (1 time) • Soil Exploration and Field Testing (1 time)	*M.Sc. in Geotechnical Engineering, Jimma University, Ethiopia*
• Pavement Materials and Construction (1 time) • Advanced Pavement Design (1 time)	*M.Sc. in Highway Engineering, Dire Dawa University, Ethiopia*
• Foundation Engineering - II • Technical Report Writing and Research Methodology	*B.Sc. in Civil Engineering, Ambo University, Ethiopia*

CONFERENCES/STTP/SEMINARS ATTENDED

1. 14 days online National level faculty development programme on "Innovative Teaching Strategies and Tools in the Digital Age" organized by Department of civil engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu from Feb 1st-14th 2024.

2. Five Days FDP on “EMERGING TRENDS IN UAV AND PRACTICAL APPLICATIONS” Jointly Organized by IEEE GRSS Bangalore Section and NIE IEEE Student Branch (NISB), Department of Civil Engineering, The National Institute of Engineering, Mysuru from 16th to 20th January 2024.

3. Indian Geotechnical Conference IGC, organized by Department of Civil Engineering, IIT Roorkee from 14th to16th December 2023.

4. International Conference on Sustainable Infrastructure: Innovations, Opportunities and Challenges - 2023 (SIIOC - 2023) organized by National Institute of Technology Karnataka, Surathkal on 20th to 21st April 2023.

5. Indian Geotechnical Conference IGC, Cochin, 15th to 17th December 2022.

6. IndoAmerican workshop on, “Multi Hazard Disaster Mitigation”, 14th December 2022.

7. National seminar on "Geotechnics for Infrastructure Development" organised by Department of Civil Engineering, NIE Mysuru and also organised as 'Organising Secretary" on 5th September 2022.

8. International conference on "Innovation in smart and sustainable infrastructure" organised by Civil Engineering Department, PDPE University, Gandhinagar on 23rd to 25th August 2022.

9. National Seminar on "Applications of Geosynthetics and Natural Fibers in Infrastructure Development" organised by Department of Civil Engineering, IIT Madras on 24th June 2022.

10. National workshop on "Recent Advances in Geotechnics for Infrastructure" organised by VVCE Mysuru on 28th May 2022.

11. Successfully completed Skill Development and Training Course on "Applications of Geosynthetics in Civil Engineering Projects" organized by IISc Banglore, IIT Madras and IIT Roorkee from 17th to 28th January 2022.

12. Indian Geotechnical Conference IGC, IGS Trichy Chapter and NIT Trichy, 16th to 18th December, 2020.

13. Participated and successfully completed the 5-day online FDP on the theme “Inculcating Universal Human Values in Technical Education” organized by All India Council for Technical Education (AICTE) from 14th to 18th June, 2021.

14. Indian Geotechnical Conference IGC, Andra University, Vishakpattanam, 17th to 21st December, 2020.

15. International Workshop of Technical Committee 213 on “Scour and Erosion” organised on December 16th, 2020 by International Society for Soil Mechanics and Geotechnical Engineering in association with Indian Geotechnical Society and Department of Civil Engineering, Andhra University College of Engineering, Visakhapatnam, India.

16. One Week online FDP on "Infrastructure Works: Site Survey to Execution Using Modern Project Management Techniques" organised by DSATM, Banglore from 10th to 15th August 2020.

17. One week online short-term course on "Emerging trends in Highway Engineering and Infrastructure Development" organised by Department of Civil Engineering, NIT Jalandhar, from 23th to 27th June 2020.

18. Five days online FDP on "Technologies for Infrastructure planning, design, monitoring and management", organised by Nalla Malla Reddy Engineering College, Divya Nagar, Medchal, Hyderabad, from 16th to 20th June 2020.

19. FDP on "Current Research Avenues in Civil Engineering" organised by Tontadarya College of Engineering, Gadag, on 29th to 31st May 2020.

20. Webinar on "Outcome based education-Road map to E-learning and Accreditation", by IIIT Banglore, on 29th May 2020.

21. Webinar on "Foundation Settlement using empirical correlations" by Prof. C. H. Solanki, organised by IGS Guntur chapter on 16th May at 6.00 pm.

22. National webinar workshop series on "Recent Advances in Geotechnics for Infrastructure RAGI2020" from 14th to 17th May 2020 by Prof. Madhav, Er. Mohan Prasad, Er. Anirudhan and Prof. G. R. Dodagoudar.

23. Webinar on "Various reinforced soil walls and slope systems", by Dr Ratnakar Mahajan, Maccaferri on 15th May.

24. Webinar series by Geopier on "Ground improvement solutions for the Transportation sector", 12th May, 2020.

25. Indo-China Research webinar series in Civil and Environmental Engineering, 8th to 19th May 2020, in association of Shantou University, China and Vardhman Engineering College, Hyderabad.

26. Webinar series by Geopier on "Ground improvement solutions for liquefaction mitigations",

7th May 2020.

27. Webinar on "Construction and quality control of reinforced soil wall", by Er. D. V. Bhavann Rao, Rtd. Chief Engineer on 30th April 2020.

28. Webinar on "Geogrid reinforced pavements-IRC SP59 2019" by Er. Deeraj Reddy, Techfab India on 30th April 2020.

29. Webinar on "How to use MacSTARS W4.0 - A versatile reinforced soil software" by Rudra Budhbatti, Maccaferri on 30th April 2020.

30. Webinar on "CASE STUDY- Verification and Foundation solution to high rise building" by Dr. C R Parthsarathy, on 29th April at 2020.

31. Burmister lecture on "Limit state design framework for reinforced slopes and walls" by Prof. Dov Leschinsky, University of Delaware & Adama engineering, USA on 29th April 2020.

32. Webinar on "Innovative flexible two-stage MSE wall solution to address soft ground and land subsidence geohazards", by Dr. Naresh Samtani, NCS GeoResources, USA, conducted by IIT Gandhinagar on 27th April 2020.

33. Webinar on "How to avoid Reinforced Soil wall failures", by Er. Yeshodeep Patil, Strata India on 24th April 2020.

34. Webinar on "Reinforced soil walls: Time to analyse and review", by Dr. Rajic Goel, CEPT University on 20th April 2020 2020.

35. Indo-Korean Workshop on “Geotechnical Issues for Urbanisation” Le Meridien Hotel, Surat, India, 18th December 2020.

36. Indian Geotechnical Conference, Marriott Hotel, Surat, India,19-21st December, 2019

37. Fifteen Days GIAN Course on “Design and Analysis of MSE Walls” IIT Patna, Bihar, 29th July to 10th August 2019.

38. One Day International Seminar on “Sustainability in Geoenvironmetal Engineering” Patna, Bihar, 5th August 2019.

39. Two days Seminar on “Soil and Highway Material Testing” Indore, MP, 30-31st August 2019.

40. International conference on Recent Trends in Engineering and technology and the Quest for sustainable development, Ambo University, Ethiopia, 3th – 14th May, 2019.

41. One Day International workshop on, “Fibre Reinforced Soil” by Prof. S. J. Shukla, SVNIT,

Surat, 22nd September 2018.

42. Two Days National DFI seminar on, “Pile Foundation analysis and Design” SVNIT, Surat, 27th to 28th May 2017.

43. Two Days International symposium on, “Emerging Technologies for sustainable development” BEC, Bagalkot, Karnataka, 27th to 28th February 2017.

44. Indian Geotechnical Conference, IIT Madras, Chennai, 15th to 17th December 2016

45. One Day Workshop on, “Deep Foundations in Liquefiable Soils and Deep Excavation Experiences” IIT Madras, Chennai, 14th December 2016.

46. International Forensic Geotechnical Engineering Conference, IISc Banglore, 8th to 10th December, 2016.

47. One Week Workshop on, “Geotechnical Aspects of Foundation Engineering” SVNIT, Surat, 17th to 21st October 2016.

48. One Day Seminar on “Soil contamination by Industrial waste”, Institute of Engineers, Vadodara, 1st October 2016.

49. International Geotechnical Engineering Conference on “Sustainability in Geotechnical Engineering Practices and Related Urban Issues”, IIT Bombay, Mumbai, Maharashtra, 23rd to 24th September 2016.

50. National Seminar on “Geotechnical Engineering”, SVNIT, Surat, Gujarat, 20th to 21st August, 2016.

51. International Conference on “Soil and Environment”, IISc Banglore, Karnataka, 22nd to 23rd July 2016.

52. Two days training programme on “Geotechnical Investigations, Interpretations & Improvements (GIII-2016)” SVNIT, Surat, Gujarat, 8th to 9th April 2016.

53. Workshop on “Outcome Based Education” BEC, Bagalkot, Karnataka, 19th to 20th February 2016.

54. International (Speaker) Training Course on “Introduction to Geosynthetics and Their Application (ITCIGA-2015)” SVNIT, Surat, Gujarat, 14th December 2015.

55. Faculty Development Program on “Active Cooperative Learning and Teaching”, IIT Madras, Chennai, Tamilnadu, 12th to 14th October 2015.

56. One Week Workshop on “Geotechnical Investigations, Interpretations and Improvements

(GIII 2015)” SVNIT, Surat, Gujarat, 14th to 18th July 2015.

57. Three days “Human Resource Development Programme”, BEC, Bagalkot, Karnataka, 25th to 28th February 2015.

58. Finishing school cum workshop on “Geotechnical Aspects of Foundation Engineering”, SVNIT, Surat, Gujarat, 9th to 11th October 2014.

59. Ten Days Workshop on “Advances in Geotechnical Engineering (AGE – 2014)” SVNIT, Surat, Gujarat, 25th June to 4th July 2014.

60. International Conference on “Latest Trends in Civil, Structural, Environmental and Infrastructure Engineering” Chennai, Tamilnadu, 8th to 10th March, 2014.

61. Finishing School Cum Workshop on “Ground Improvement Techniques”, SVNIT, Surat, Gujarat 11th to 12th February, 2014.

62. Forth International Conference on “Solid Waste Management”, Hyderabad, Andra Pradesh, 28th January, 2014.

63. International Conference on “Advances in Engineering and Technology”, Nagpur, Maharashtra, 8th to 9th January 2014.

64. Second International Conference on “Sustainable Innovative Techniques in Civil and Environmental Engineering” Jawaharlal Nehru University, New Delhi, 5th January, 2014.

65. Indian Geotechnical Conference 2013, IIT Roorkee, Uttarakhand, 22nd to 24th December 2013.

66. International Conference on “Emerging Trends in Civil and Mechanical Engineering” Siliguri, West Bengal, 10th November 2013.

67. Workshop on “Geotechnical Investigations, Interpretations and Improvements” SVNIT, Surat, Gujarat, 18th to 22nd October 2013.

68. National Seminar on “Advances in Geotechnical Engineering” SVNIT, Surat, Gujarat, 7th to 9th June 2013.

69. Summer internship for period of 8 weeks under Dr. G.R. Dodagoudar, IIT Madras, Chennai, Tamilnadu, August to June 2013.

70. 4th Young Indian Geotechnical Conference (4IYGEC), IIT Madras, Chennai, Tamilnadu, 17th to 18th May 2013.

71. Workshop on “Finite Element Modelling with MATLAB” SVNIT, Surat, Gujarat, 6th to 10th May 2013

72. One Day Finishing Scholar on “Overview of Ground Improvement Techniques” SVNIT, Surat, Gujarat, 23rd April, 2013

73. Workshop on “LANDFILLS” IIT Delhi, New Delhi, 6th to 7th March 2013.

74. Finishing School cum Workshop on “Ground Improvement Techniques” SVNIT, Surat, Gujarat, 11th to 12th February 2013.

75. Structural Engineering Convention (SEC-12) SVNIT, Surat, Gujarat, 19th to 21st December, 2012

76. Indian Geotechnical Conference 2012, IIT Delhi, New Delhi, 13th to 15th December 2012.

77. Indo-Korean workshop on “Geotechnology for Urban Development” IIT Delhi, New Delhi, 12th December 2012.

78. National level conference on “Civil and Chemical Engineering” Bapuji Institute of Technology, Davangere, Karnataka, January, 2011.

79. National level technical conference on “Emerging Engineering Techniques” KIT’s College of Engineering, Kolhapur Maharashtra, October, 2010.

80. National level conference on “Civil and Environmental Engineering” Malnad College of Engineering, Hassan, Karnataka, September, 2010.

81. State level conference on “Civil Engineering” Malnad College of Engineering, Hassan, Karnataka, July, 2009.

EXPERT / INVITED TALKS DELIVERED

1. Expert speaker at One day National Seminar on "Recent Advances in Geotechnical Engineering (RAGE) - 2023" organized by Indian Geotechnical Society Surat Chapter in association with Department of Civil Engineering, SVNIT Surat, Indian Geotechnical Society Student Chapter SVNIT and Indian Geotechnical Society Student Chapter SCET on 15th October 2023.

2. Expert Speaker at Five Days Faculty Development Program (FDP) on “Research Insights in Civil Engineering (RICE – 2023)”, organised by Dept of Civil Engineering, NIE Mysuru on 27th July 2023.

3. Invited as Guest speaker on “Importance of Higher Education and Career Opportunities” organized by Training and Placement cell, The Oxford Group of Institutions, Bengaluru on 2nd June 2023.

4. Resource Person at One week Faculty Development Program on EMERGING TRENDS AND PROSPECTS IN GEOTECHNICAL ENGINEERING 19th - 24th December 2022, Organized by Department of Civil Engineering, S. G. Balekundri Institute of Technology, Belagavi
5. Expert Speaker at National seminar on "Geotechnics for Infrastructure Development" at NIE Mysuru on 5th September 2022.

6. Expert Speaker for webinar on “An overview of ground improvement techniques with some case histories - Geosynthetics, Soil Nailing and Micro Piles” organised by Faculty of Technology, CEPT University, Ahmedabad on 09/10/2021.

7. Guest Lecture at Department of Civil Engineering, NIT Surat for M.Tech second year Geotechnical Engineering students on Research and Career opportunities on 25/04/2022.

8. Speaker in SDP on "Job Opportunities & Higher Studies in Civil Engineering" organised by Dept of Civil Engineering, NIE Mysuru on 10th January 2022.

9. Expert Speaker for webinar on “Recent Applications of Geosynthetics in Civil Engineering Projects” organised by Faculty of Technology, CEPT University, Ahmedabad on 9th October 2021.

10. Invited as Expert Speaker for webinar on “Applications of Geosynthetics in Civil Engineering Projects” organised by IGS Surat Chapter and IGS Student Chapter, SVNIT, Surat on 25/07/2021.

11. Delivered an expert talk on "Interlocking Stabilised Soil Blocks - Appropriate Material and Method for Construction Rural Areas" as Resource Person in One Week FDP on "Precast and Sustainable Technologies" organised by JB Institute of Engineering and Technology, Hyderabad on 23rd April, 2021.

12. Guest Lecture on Career opportunities and Guidance for Civil Engineering Students on 15th January 2021, organised by Department of Civil Engineering, KLE Dr. M. S. Sheshgiri College of Engineering & Technology, Belagavi.

13. Presented a webinar talk on “Career Opportunities in Civil Engineering: Global and Domestic Scenario” at Biluru Gurubasava Mahaswamiji Institute of Technology, Mudhol, Karnataka. The talk was held on the eve of Engineer’s Day, 23/10/2020.

14. Talk on "Guidelines for Career in Civil Engineering", in online workshop on Career Opportunities and Guidance organised by NIE Mysuru on 14th July 2020.

15. Expert E-Talk in Webinar on "Introduction to Applications of Geosynthetics in Civil Engineering Projects" on 31st May 2020 organised by Amritvani College of Engineering, Sangmner, Maharashtra.

16. Invited talk on "Applications of Geotechnics in Civil Engineering Practice" at SKSVM Agadi College of Engineering, Laxmeshwar, Gadag on 17th September 2019.

17. Keynote Address at Ambo University, Ethiopia on "Research Publications" on Research Review Day on 24th May 2019.

18. Invited talk at BGM Institute of Technology, Mudhol, Karnataka, India on "Importance of Higher Education" 0n 13th August 2018.

19. Invited talk at BGM Institute of Technology, Mudhol, Karnataka, India on "What next after B.E / B.Tech" on 3rd March 2017.

20. Invited talk at Rural Engineering College, Hulkoti, Karnataka, India on "Career Opportunities and importance of GATE" on 13th April 2017.

MEMBERSHIPS IN PROFESSIONAL BODIES

Life Member of Association of Consulting Civil Engineers (INDIA) - Member ID: 5466-L
Member of International Society of Geosynthetics. Member ID: 11584
Life Member of Indian Geotechnical Society. Member ID: LM 4474
Member of International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE).
Associate Member of American Society of Civil Engineers (ASCE) - India Southern and Western Section. - Member ID: 9776411
Associate Member of The Institute of Engineers India. - Member ID: AM1838418
International Association of Engineers (IAENG) - Member ID: 254581
Life Member of Teaching and Education Research Association (TERA), Member ID: TERA-M110584
Associate Member of Geo Institute of ASCE

REVIEWER / EDITORIAL MEMBER

1. Reviewer of "Patents in Engineering" Journal (Scopus)
2. Reviewer of American Journal of Civil Engineering
3. Reviewer of Advances in Science, Technology and Engineering Systems Journal
4. Editorial Board Member of International Research Journal of India
5. Editorial Board Member of Advances in Engineering – An International Journal
6. Editorial Board Member International Open Journal of Science and Engineering
7. Reviewer of International Journal of Engineering Research and Technology

M.Tech THESES AWARDED UNDER MY GUIDANCE AS MAIN ADVISOR

1. Ashwini. A. Landslide Risk Assessment and Mitigation, 2016
2. Bharamagoud. B. Experimental Study of Heave Control Technique for Expansive Soil Using Micropiles, Geotextile Layers and Bio Enzyme, 2016
3. Mahesh. C. Bearing Capacity Improvement by using Geonet and Geogrid, 2016
4. Sangamesh. K. Numerical and Analytical Analysis of MSE Wall, 2016
5. Shashidhar. H. Comparative Study on Stabilization of Expansive Soil Using Fly Ash, Rice Husk Ash, Bagasse Ash & Marble Dust, 2016
6. Shilpa. V. Static and Seismic Analysis of MSE Wall, 2016
7. Vijayvardhan. R. Prediction and Simulation of Contaminant Transport Modeling, 2016
8. Deepali. G Numerical Study on Prediction of Behaviour of Braced Excavation in Heterogeneous soil, 2017
9. Sahana. A. Performance of Reinforced Earth Walls with Rammed Aggregate Pier, Pile Foundation and Drilled Shaft as Supporting System, 2017
10. Soumya. Y. Seismic Response Analysis of Gravity Retaining Wall for Homogenous and Heterogeneous Foundation Soil, 2017
11. Akshata. A. Enhancement of Index and Engineering properties of Expansive soil by Basalt Fibres and Silica Fume, 2017
12. Ashwini. S. Experimental Investigation on Viability of Metakaolin based Stabilized/Solidified Lead Contaminated Soil, 2017
13. Avinash. A. Improvement of Bearing Capacity of Sand with Geocell Reinforcement of Different Stiffnesses, 2017
14. Raghavendra. R. Comparative Study on Behaviour of MSE and Conventional Retaining wall for Different Earthquake Conditions, 2017
15. Sneha. P. Experimental Investigation on Geotechnical Properties of Chromium Contaminated Soil by Alco fine, 2017
16. Mulugeta Regassa. Characterisation of subgrade soil for flexible pavement design: The case of Arbaminch – Konso road, 2019
17. Hiruy Getahun. Investigation on engineering properties of a soil and its improvements at subgrade: Case study of Addis Ababa to Nairobi Corridor (Chuko to Yirgachefee), 2019
18. Yitakel Assfaw. The assessment of effects of deep excavations on adjacent structures using FE program: A case study in Addis Ababa, Hawassa University Geotechnical Engineering, 2020
19. Kibrom Negasi. Gebreyesus. Numerical Simulation of Vane Shear Test using Finite Element Hawassa University, Geotechnical Engineering, 2020
20. Ashenafi Tefera. Comparative analysis of Gravity retaining wall and MSE wall under different seismic conditions, Arba Minch University, Geotechnical Engineering, 2020
21. Abebe Edosa Toli. Investigation of some Engineering properties of Soil in Adama town and Geotechnical data management by GIS software, Jimma University, Geotechnical Engineering, 2020
22. Rameto Tusa. Evaluation of Alternative stabilisation techniques and developing swelling potential prediction model for expansive soil in Worabe town Hawassa University, Geotechnical Engineering, 2019
23. Zemu Gina. Evaluation of Liquefaction Potential of soil near lake Hawassa, Hawassa University, Geotechnical Engineering, 2019
24. Malluraj Hitni. Landslide Studies of Coorg District, Karnataka, NIE Mysuru, Water Resource Engineering, 2021

25. Anitha. Seismic Response Analysis of High-Rise Building considering soil-structure interaction, 2022
26. Sanjeevini B Akki. Effect of Bracings on the Performance of High-Rise Structure Considering the Influence of Earthquake, 2022 (Co-Advisor)
27. Basavaraj C S. Effect of Foundation Types on the Dynamic Performance of Onshore Wind Turbines considering the effect of Soil-Foundation-Structure Interaction, 2023
28. Dhariyappa Dhoolappanavar. Wind Analysis of Tall Reinforced Concrete Chimney Considering the effect of Soil Structure Interaction, 2023

SOFTWARE PROFICIENCY

1. FLAC 2D/3D
2. PLAXIS 2D / 3D
3. MATLAB
4. REAME - Slope Stability Analysis
5. GRLWEAP- Pile Driving Analysis
6. GEOSTUDIO 2014
7. SOIL VISION OFFICE 2009
8. GEO 5
9. MODFLOW
10. QUAD4
11. TALREN
12. AUTO CAD

ACADEMIC RESPONSIBILITIES

1. Research Ambassador, Dept. of Civil Engineering, NIE Mysuru (2023-2024)
2. Honorary Secretary for Indian Geotechnical Society, Mysuru Chapter (2023-Till Date)
3. Student Club Coordinator at Department level at NIE Mysuru (2022-2023)
4. Career Guidance Coordinator at Department level at NIE Mysuru (2022-2023)
5. Training and Placement Coordinator at Department level at NIE Mysuru (2020-2022).
6. Coordinator for establishment of new PG geotechnical engineering program at Ambo University (2018-19).
7. Chief Coordinator for Centre of excellence and incubation at Ambo University, Ethiopia (2018-19).
8. Member of Graduate Engineering Committee for PG studies at Ambo University, Ethiopia (2017-19).
9. Faculty Advisor, Faculty of PG Geotechnical Engineering Studies, Basaveshwar Engineering College, Bagalkot (2015-17).
10. Member, Anti Ragging Committee, Basaveshwar Engineering College, Bagalkot 2016 (2016-18).
11. HRD Trainer for many UG and PG students at various engineering colleges in India. (2015-17).
12. National Board of Accreditation Coordinator for Faculty of PG Geotechnical Engineering

Studies, BEC BGK (2015-17).

CONTACT DETAILS

Permanent Residential Address:
236/1, Laxmi Nagar, Near Rural Police Station
Bagalkot, Karnataka, India – 587 101

PROFESSIONAL REFERENCES

Prof. C. H. Solanki
Professor,
Department of Civil Engineering,
NIT Surat
Ph. No. 99252 07 068
Email Id: chs@amd.svnit.ac.in

Prof. Deepankar. Choudhury
Professor and Head,
Department of Civil Engineering,
IIT Bombay
Ph. No. 99692 74031
Email Id: dc@civil.iitb.ac.in

Prof. G. R. Dodagoudar
Professor,
Department of Civil Engineering,
IIT Madras
Ph. No. 98403 28754
Email Id: goudar@iitm.ac.in

Prof. Krishna Reddy
Professor & Director,
Civil, Materials, and Environmental
Engineering Department
University of Illinois
Chicago, USA

II) Details of Dr. Deepak Manjunath

1	**Invite Id**	1895546313
2	**Name**	Deepak Manjunath
3	**Email ID**	deepak.manjunath@terre-armee.com
4	**Alternate Email**	deepakmanju@yahoo.com
5	**Mobile Number**	7574887547
6	**Address**	Reinforced Earth India Pvt Ltd E-11, Block B1 Extension, Mohan Co-operative IndustrialEstate, Mathura Road, New Delhi-110044, New Delhi, DELHI, India
7	**Organization Name**	Terre Armee India, New Delhi
8	**Designation**	Manager - Specification Engineering
9	**Other Relevant Information**	Vice President, Design & Engineering
10	**Download Cv Docs**	
11	**Organization Authorization Letter**	

Educational Qualification :

Sl No.	**Degree**	**Institute Name**	**Passing Year**
1	Graduate	VTU Belagavi Karnataka	2011
2	Post Graduate	SVNIT Surat	2014
3	Doctorate	SVNIT Surat	2021

Experience of R & D projects undertaken :

Sl No.	**Project Name**	**Institute Name**	**Research File**
1	NA	NA	

Papers Published (Not more than 3 important ones) :

Sl	**Title**	**Publisher**	**Year**	**File**

No.				
1	Seismic Internal Stability Analysis of Modular Block Reinforced Earth Retaining Wall	International Journal of Geosynthetics and Ground Engineering, Springer	2023	
2	Finite Element Analysis of Segmental Precast Panel Reinforced Earth Retaining Wall	Jordan Journal of Civil Engineering	2023	
3	Numerical analysis of pile group, piled raft, and footing using finite element software PLAXIS 2D and GEO5	Scientific Reports, Natur	2023	

Applied in following departments :

Sl No.	Technical Department	Technical Committee	Status
1	Civil Engineering Department (CED	Hill Area Development Engineering (56)	Pending
2	Textiles Department (TXD)	Geosynthetics (30)	Pending
3	Civil Engineering Department (CED)	Soil And Foundation Engineering (43)	Pending
4	Civil Engineering Department (CED)	Earthquake Engineering (39)	Pending
5	Civil Engineering Department (CED)	()	Pending
6	Civil Engineering Department (CED)	()	Pending
7	Civil Engineering Department (CED)	Electronic Measuring Instruments, Systems And Accessories (8)	Rejected

CV OF DR. DEEPAK MANJUNATH

Dr. DEEPAK MANJUNATH

E-mail: deepak.manjunath@terre-armee.com Phone: +91-7574887547

Dr. Deepak Manjunath has a PhD in Geotechnical Engineering and has a total of 15 years of experience in the fields of Geotechnical Engineering, Geology, Transportation Engineering. Through the course of his Geotechnical Engineering, he has held several technical managerial positions and has been responsible for design, site characterization, technical analyses, project management, cost estimating, Geosynthetics application & testing and Engineering team management.

His design experience includes Design of Gravity Retention structures and Reinforced Soil Walls & Slopes in accordance with International and Domestic codal standards (BS 8006:2010, FHWA-NHI-10- 024 & FHWA-NHI-10-025, IRC SP 102:2014 , IS 1893:2003).

His experience with Geotechnical Design & Analysis software includes experience with SLOPE/W, UTEXAS, SLIDE, PLAXIS, LPILE, GRLWEAP, DRIVEN, SEEP/W, Two-dimensional Coulomb Stress computation software, MSEW, ReSSA and FoSSA besides several custom made spreadsheets for design of ground improvement using Geosynthetics.

EDUCATION:
Ph. D., Civil Engineering - Geotechnical Engineering (2008)
University of Missouri- Columbia, MO, USA.
M. S., Geological Sciences (2008)
University of Missouri- Columbia, MO, USA.
M. S., Civil Engineering - Transportation Engineering (2002)
University of Missouri- Columbia, MO, USA.
B. Tech., Civil Engineering (1999)
National Institute of Technology, Surat, India

WORK EXPERIENCE:

Terre Armee India Pvt. Ltd.
Vice President - Design & Engineering **August 2019 – present**

▪ Project co-ordination, planning, interaction with client for collection of input data
▪ Preparation and Issuance of Design Reports for Reinforced Earth Walls
▪ Co-ordination with client/consultant for approval of design and drawing
▪ Preparation of BOQ (Bill of Quantities) / Variance Analysis Report
▪ Preparation of monthly "Design and Drawing" Activity Sheet Report
▪ Supervise and monitor activities of CAD Department, timely and error free generation and dispatch of drawings
▪ Preparation of proposals, case study and preliminary design for cost estimation.
▪ Interfacing with Business Managers on technical proposals
▪ Developing soil investigation procedures and design parameters for MSE Walls and Precast Structures
▪ Supervising, supporting, mentoring, and training members in the team including junior engineers
▪ Contributing to development of design engineering technology and tools & training further team members
▪ Checking quality and content of engineering deliverables with regard to the geotechnical
side

Ensuring compliance with corporate and project QMS and HSES procedures

Geotechnical Consultant (Independent) **April 2019 - August 2019**

Z-Tech India Pvt. Ltd. – Delhi, India **March 2018 – April 2019**
Head of Technical Department

Job Duties:

Head the technical department of the company through timely, effective and efficient technical support for Business Development activities as well as bagged projects involving design, supervision and/or execution of projects involving use of geosynthetics viz.

- Mechanically Stabilized Earth Walls using Segmental Panel, Modular Block and Gabion facia,
- Mechanically Stabilized Earth Slopes using geosynthetic wrapped around geotextile bags as well as mechanically woven mesh wrap around systems,
- Efficient drainage by means of drainage composite and ground improvement by means of basal reinforcement,
- Acceleration of consolidation using Wick Drains,
- Track bed stabilization using Geogrids,
- Pavement reinforcement using Glass grids,
- Canal lining using geosynthetic concrete grout mattress and
- Erosion control of earthen slopes using Geotextile bags.

Responsibilities also include:

- Approval of Design and Drawings before delivery to the client. Technical guidance to clients when necessary.
- Coordination with site personnel (internal construction team / external contractor) to clarify design matters and to incorporate deviations in design conditions observed during progress of work at site and to initiate design and BoQ revisions when necessary.
- Obtaining technical approval of designs from third-party design vetting bodies when required.
- Developing resources and updating the knowledge base on engineering design practices as per international and national advancements in technology through continuous training programs (on the job training).

Geosynthetic Testing Services Pvt. Ltd. – Ahmedabad, India **Jan 2015 – March 2018**
(A Joint Venture company of TRI Environmental Inc,, USA
& BTTG Testing & Certification Ltd, UK)

Operations Head
Job Duties:

- Successfully implemented the standard test procedures as per ASTM, ISO & other National Standards for various Index and Performance Tests of Geosynthetics products (Reinforced and Unreinforced Geomembranes, Woven and Nonwoven Geotextiles, Uniaxial and Biaxial Geogrids, Drainage composites, Wick Drains, Geosynthetic Clay Liners) viz. Density, Carbon Black Content, Carbon Black Dispersion, Strip, Grab and Wide-width Tensile Properties, Tear Resistance, Puncture Resistance,, Stress Crack resistance (NCTL), Permittivity and Permeability by Constant or Falling Head methods, Transmissivity / In-plane flow, Apparent Opening Size, Characteristic Opening Size, Interface Friction

Angle of Geogrids and Geostrips, Derivation of Installation damage and Creep Reduction factors for designing with geosynthetics along with achieving accreditation of the testing facility under Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP, USA) within a year of commissioning of test equipment.

- Technical training and supervision of staff, and to provide effective technical services as per recognized and accredited standards of quality and accuracy.

- Regular interaction and follow-up with existing and prospective clients to build pipeline of regular testing work.

Maccaferri Environmental Solutions Pvt. Ltd. **Feb 2011 – Jan 2015**

Divisional Manager – Design, Pune & Gurgaon, India Feb 2011 – Jan 2015

Job Duties:

- Final Checking, approval of designs and drawings before delivery to the client and interacting and convincing clients whenever necessary
- Design of Gravity Retention, Hydraulic and Erosion control structures and Reinforced Soil Walls & Slopes in accordance with International and Domestic codal standards (BS 8006:2010, FHWA-NHI-00-043, SANS 1580:2010, IS 1893:2003)
- Leading a team of around 30 Engineers and coordination of design and drafting activities for Maccaferri subsidiaries spread across the globe viz.India, Italy, France, Central Europe, Spain, USA, UK, Australia & New Zealand, as per respective national andinternational standards.
- Coordination with site personnel (either internal EPC wing or external contractor) to clarify design matters and to incorporate deviations in design conditions observed during progress of work at site and to undertake design and BoQ revisions when necessary.
- Technical approval of designs from third-party design vetting bodies when required.
- Developing resources and updating the knowledge base on design and drafting practices as per the international and national advancements in technology through continuous training Programs (on the job training)

Some key projects:

- ***Four Laning of Kiratpur-Ner Chowk section of NH-21 in state of Punjab / Himachal Pradesh:***Four Laning of Kiratpur to Ner-Chowk Section of NH-21 from Km 73.200 to Km 186.500 in the States of Punjab & Himachal Pradesh, executed as BOT (Toll) on DBFO pattern under NHDP Phase – III

  Design and construction coordination for reinforced soil structures varying in height from 10 m to 45 m. This is a typical hill road project in Seismic Zone – V where all reinforced soil structures support the NH-21. Was also responsible for design approval from Independent Engineer.

- ***River Bank protection and storage capacity augmentation at Joshiyara Barrage, Uttarakhand:***

  Design and construction coordination for river front gravity retention structure and scouring apron undertaken to increase storage capacity at Joshiyara barrage location on the banks of River Bhagirathi.Also responsible for design approval from Central Building Research Institute (CBRI), Roorkee.

- ***Enhancement of Red Mud storage capacity project for Hindalco, Muri, Jharkhand:***

  Design and construction coordination for construction of reinforced soil structures at Hindalco, Muri, Jharkhand to enhance red mud storage capacity. Also responsible for design approval from CBRI, Roorkee and provided technical support to Hindalco to obtain system clearance from Central Pollution Control Board (CPCB).

Earth Retention structures for South Western Railways Nelamangala Bangalore:

Design finalization and approval from South Western Railway design wing for gravity retention structures along Nelamangala section of South Western Railway line in outskirts of Bengaluru.

- ***DLF Panchkula***
  Design and construction coordination for construction of reinforced soil structures at DLF housing project in Panchkula. Also responsible for design approval from IIT Roorkee.

- ***Retaining structures for North Toll Plaza and Dump area, Chenani Nashri Tunnel project***
  Design and construction coordination for construction of reinforced soil structures at North Toll Plaza and Dump Area locations of $500m Chenani-Nashri Tunnel Project.

- ***Mountain Road Project – Ras Al Khaimah, UAE***
  Design coordination for retention structures to support highest road in UAE. The entire stretch consists 36 km of road with a maximum structure height of 32m. All initial designwork for approval of project was done in the design center in India under my supervision. Was also responsible to answer technical clarifications sought by Halcrow International Partnership during approval stage. The project under Maccaferri Middle East was winner of GeoME award in 2015 in the category “Best Geosynthetics Project”.

Some key techno-commercial proposals:

- Runway extension at Bhuntar Airport by river diversion, Kullu, Himachal Pradesh. Proposal
- submitted to Airports Authority of India.
- River front development at Chauras campus of HNB Garhwal University along river Alaknanda. Proposal submitted to HNBGU campus.
- DPR for Uttarakhand flood disaster mitigation. Proposal submitted to PWD, Uttarakhand.
- Flood protection work at Mangala processing terminal in Rajasthan block. Proposal submitted to Cairn India.
- Erosion control and scour protection for Gangapath in Patna, Bihar.
- Enhancement of storage capacity at Hindalco, Renukoot. Proposal submitted to Hindalco, Renukoot.
- River bank protection works near Joshiyara barrage, Uttarakhand. Proposal submitted to PWD and UJNVL, Uttarakhand.

- Development of new airport at Kannur. Proposal submitted to KIAL and L&T.
- Jammu Central University. Proposal submitted to Jammu Central University.

GEODATA – Delhi, India **Nov 2010 – Jan 2011**
Geotechnical Engineer

- Chenani – Nashri Tunnel Project: It is a $500m contract to build a tunnel in India’s Jammu region. Geodata had been charged by Leighton with the responsibility of developing the detailed design and doing the subsequent construction follow up of the Patnitop Tunnel.

o Responsible for reporting, monitoring and execution of all the site activities including preparation of daily and weekly reports, client liaison and attending project meetings.

URS Corporation – Denver, Colorado, USA April 2008 – July 2010

Geotechnical Engineer
Job Duties:

- City of Dallas Pump Station Levees: Geotechnical Design and Analyses as part of 35% design level effort. Task leader of Geotechnical Analysis Group (Shear strength characterization, Seepage
- analyses, Slope stability analysis and Consolidation & Settlement analysis).
- New Orleans Levees: Investigation for levee upgrade and Seepage analysis to estimate design safe
- water levels at Inner Harbor Navigation Canal (IHNC) Reach II. Role includes assigning laboratory tests (UU, CU, CU', Consolidation, etc.) and seepage modelling using GeoStudio.
- Natomas NWS Levees: Evaluation of geotechnical design and analyses performed for the project.
- Role includes seepage analysis and slope stability analysis for reach 4.
- Hefner Dam: Geotechnical investigation and design of a surficial slope failure at Hefner Dam. Role includes prepare and execute geotechnical investigation plan and perform slope stability and seepage analysis to provide recommendations.

B) CO-OPTION REQUEST FROM SHAHI GARG

SHAHI GARG

shahigarg220@gmail.com,
7990483766

Kakadiya complex, ghod dod road,
Surat-395007; GUJARAT.

OBJECTIVE

I seek challenging opportunities where I can fully use my skills for the success of the organization.

EDUCATION

2017	**St.Mark's High School** SSC 77%
2019	**H.M.Bachkaniwala High School** HSC 61%
2023	**The Maharaja Sayajirao University** Bachelor of Engineering 82%

PROJECTS

- Influence of different alkali on dyeing of cotton with homo-functional reactive dyes

SKILLS

- Communication skills, Computer knowledge, Time management, Leadership skill.

ACHIEVEMENTS & AWARDS

- Gold medalist in B.E. Recevied 1st Rank certificate from MSU vision. Awarded by ACTI (Association of chemical Technologists-India) for 1st Rank. Got Miss Fresher Award. Proudly, I had represented my university (MSU) in National Integration Camp and State camp. I have served as National Service Scheme (NSS) Coordinator. Our project got published in IJSRD (International Journal for Scientific Rearch and Development**).**

ACTIVITIES

- I have a strong background in community service, including visits to orphanages, old age homes, slum areas, and shelters for disabled individuals. Additionally, I have organized webinars, awareness camps, leadership camps, gaushala & many more. Industrial visits to companies like Hare Krishna Diamond Hub, Balaji Wafers, Aglon Inds. Pvt. Ltd., Donear Ind. Ltd., Ecotex, Nobletex. My active involvement with community has allowed me to organize, manage, and volunteer in various social activities. I have also attended exhibitions to broaden my understanding of diverse fields.

LANGUAGES

- English
- Hindi
- Gujarati

EXPERIENCE

10/06/2022	**ALOK IND.LTD.** Intern
18/06/2022	Grey inspection Scouring & Desizing & Bleaching Dyeing & printing Lab instruments & Testing
1/11/2023 - Till date	**Ventara Hi-Tech fabric-MNC** Quality control Manager/Lab Incharge /Lab Executive

HOBBIES

- Nature walk
  Fashion
  Music
  Reading books
  Spirituality

DECLARATION

- I have ensured that the information provided by me in this resume is true to my knowledge.

ANNEX 3
(*Item* 3.2)

Item No.	Decision Taken	Action Taken
2	Review of composition of TXD 30	Updated composition of TXD 30 is given in Annex 1.
4	**DRAFT STANDARDS/AMENDMENT FOR FINALIZATION** **4.1** In the last meeting, the committee finalized the draft standard on 'Geotextiles for Drainage, Separation, Filtration, Erosion Control and Stabilization Applications' for publication after incorporating the changes mentioned under 4.1 to the minutes. **4.2** In the last meeting the committee FINALIZED the following draft Indian Standards for publication as Indian Standards: a) Geotextiles — Methods of Test Part 2 Determination of Resistance to the Exposure of Ultraviolet Light, Moisture and Heat (Xenon-Arc Type Apaparatus) [TXD 30 (25136)] (*first revision of* IS 13162 (Part 2) : 1991) b) Geosynthetics — Method for Determination of Trapezoid Tearing Strength [TXD 30 (25137)] (*first revision of* IS 14293 : 1995) c) Geosynthetics — Method for Determination of Apparent Opening Size by Dry Sieving Technique [TXD 30 (25138)] (*first revision of* IS 14294 : 1995) d) IS 14714 Geotextiles — Determination of Abrasion Resistance [TXD 30 (25139)] e) IS 14706/ISO 9862: 2023 Geosynthetics — Sampling and Preparation of Test Specimens [TXD 30 (25140)] (*first revision of* IS 14714 : 1999) f) Geotextiles and Geotextile-Related Products — Determination of Water Permeability Characteristics Normal to the Plane, Without Load [TXD 30 (25141)] (IS 14324/ISO 11058: 2019) g) Geosynthetics — Determination of Friction Characteristics Part 1: Direct Shear Test [TXD 30 (25142)] (IS 13326 Part 1/ISO 12957 Part 1:	 Under publication Under publication

	2018) h) IS 13162 Part 4/ISO 13433: 2006 Geosynthetics — Dynamic Perforation Test (Cone Drop Test) [TXD 30 (25143)] (IS 13326 Part 1/ISO 12957 Part 1: 2018) **4.3** In the last meeting, the committee finalized the draft standard on 'Geotextile Tubes for Coastal and Waterways Protection' for publication after incorporating the changes mentioned under 4.1 to the minutes.	Under publication
5	**INTERNATIONAL ACTIVITY** **5.1** In the last meeting, the committee decided to align the Indian Standards with the latest versions of the following ISO standards, which shall be issued for wide circulation for a period of one month: i) ISO 13426-2 : 2024 Geotextiles and geotextile-related products — Strength of internal structural junctions — Part 2: Geo-composites ii) ISO/TS 20432 : 2022 Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement iii) ISO 12958-1 : 2020 Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 1: Index test iv) ISO 12958-2 : 2020 Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 2: Performance test v) ISO 12960 : 2020 Geotextiles and geotextile-related products — Screening test methods for determining the resistance to acid and alkaline liquids	The drafts were issued in wide circulation. Coming for discussion under Agenda item **5.2.**
	5.2 International Activity **A)** The committee recommended for the adoption of the following standards published by ISO TC 221 'Geosynthetics': i) ISO/TS 18198 : 2023 Determination of long-term flow of geosynthetic drains	To be issued in wide circulation.

	ii) ISO 12956 : 2019 Geotextiles and geotextile-related products — Determination of the characteristic opening size (wet sieving) iii) ISO/TS 13434 : 2020 Geosynthetics — Guidelines for the assessment of durability iv) ISO 18325 : 2015 Geosynthetics — Test method for the determination of water discharge capacity for prefabricated vertical drains v) ISO 25619-2 : 2015 Geosynthetics — Determination of compression behaviour — Part 2 : Determination of short-term compression behaviour **B)** In the last meeting the committee decided that following standards shall be reviewed by the working group TXD 30.WG03 constituted under the convenorship of Prof. Rajagopal. K., Andhra University, Visakhapatnam for their applicability, relevance and adoption in the Indian context: i) ISO/TR 18228-1 : 2020 Design using geosynthetics — Part 1: General ii) ISO/TR 18228-2 : 2021 Design using geosynthetics — Part 2: Separation iii) ISO/TR 18228-3 : 2021 Design using geosynthetics — Part 3: Filtration iv) ISO/TR 18228-4 : 2022 Design using geosynthetics — Part 4: Drainage v) ISO/TR 18228-6 : 2023 Design using geosynthetics — Part 6: Protection vi) ISO/TR 18228-7 : 2021 Design using geosynthetics — Part 7: Reinforcement vii) ISO/TR 18228-9 : 2022 Design using geosynthetics — Part 9: Barriers viii) ISO/TR 18228-10 : 2024 Design using geosynthetics — Part 10: Asphalt pavements ix) ISO 13437 : 2019 Geosynthetics — Installing and retrieving samples in the field for durability assessment x) ISO 22182 : 2020 Geotextiles and geotextile-related products — Determination of index abrasion resistance characteristics under wet conditions for hydraulic applications xi) ISO 25619-1 : 2021 Geosynthetics — Determination of compression behaviour — Part 1: Compressive creep properties	The meeting of working group TXD 30. WG03 is to be planned shortly.

6	**COMMENTS ON PUBLISHED INDIAN STANDARDS** **6.1** The Committee decided to issue draft amendment to IS 17483 (Part 2) : 2020 incorporating the changes mentioned at 6.2 to the minutes for wide circulation for one month time period eliciting the technical comments. **6.2** The committee decided that title of the standard and requirements for elongation at break, roll length, trapezoid tear strength (for filter fabric) along with their test reports will be reviewed by Smt. Dola Roychowdhury, International Geosynthetics Society, India Chapter, New Delhi, Shri Suraj Vedpathak, Strata Geosystems (I) Pvt Ltd, Mumbai, Shri Saurabh Vyas, Techfab India, Mumbai for suggesting suitable changes/modification required in the standard.	 Amendment No. 3 to IS 17483 (Part 2) has been issued under wide circulation. Inputs awaited.
7	**REVIEW OF STANDARDS** In the last meeting, the committee decided that BIS shall fill the review proforma for the standards and circulate for 10 days, based on the comments received the standards shall be reaffirmed/taken for revision.	The filled review proforma of the standards were circulated to all the committee members. In view of no comments received, the standards have been reaffirmed from their due date.

Annex 4
(*Item* 5.1)

WIDE CIRCULATION DRAFT ON 'TEXTILES — COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES FOR EROSION CONTROL APPLICATIONS — SPECIFICATION'

Doc. No: TXD 30 (25914) WC
June 2024

भारतीय मानक ब्युरो

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

भारतीय मानक मसौदा

वस्त्रादि — कटाव नियंत्रण अनुप्रयोगों के लिए बिना बुने हुए जटा के सिले मिश्रित भू-वस्त्र — विशिष्टि

Draft Indian Standard

Textiles — Coir Non-woven Stitched Composite Geotextiles for Erosion Control Applications — Specification

ICS 59.080.70

Geosynthetics Sectional Committee, TXD 30	Last date for receipt of comment is **19 August 2024**

FOREWORD

(Formal clauses will be added later)

Coir non-woven stitched composite geotextiles (CNWGT) is natural coir matrix stitched with polypropylene (PP), high-density polyethylene (HDPE) or low-density polyethylene (LDPE) netting on both sides as a homogenized fabric. Acting as a barrier between soil surfaces and rainfall, CNWGT mitigates erosion caused by rainwater and wind on road and railway embankments, mine spoil dumps, and hill slopes. By impeding surface runoff, it prevents the displacement of soil particles containing seeds and nutrients, thus facilitating the growth of vegetation and stabilizing slopes. The selection of CNWGT for a geotechnically stable slope against surface run off, basically depends on type of soil, slope and extreme rain fall in limited time span. The impact of raindrops and surface wind on exposed soil surfaces can trigger surface runoff, carrying away soil particles along with seeds and nutrients, inhibiting natural vegetation growth.

CNWGTs are permeable fabrics made from natural coir fiber with netting on both sides stitched with mono filament or multi filament yarn, controls soil erosion by providing a protective ground cover which is in firm contact with soil and arrests the surface flow of rain water, reducing rain splash erosion and controlling the flow velocity of runoff water.

The village roads where the traffic is less are usually unpaved. The deformation of unpaved road on soft sub grade will be higher due to high axial loads. The sub-grade strength is normally expressed in terms of its California Bearing Ratio (CBR) value. During rainy season in the absence of any bond between different layers of soil particles, the fine soil particles may penetrate from one layer to another. Due to high hydrostatic pressure which leads to formation of large depression or potholes. Also due to poor bearing capacity of the soil foundation the sub-base soil undergoes large deformation. To prevent local shear failure, either increase the thickness of the base layer or improve the sub grade through stabilization.
Another effective measure is the application of coir non-woven stitched composite geotextiles, which can improve the characteristics of unpaved roads.

1 SCOPE

1.1 This standard prescribes the specifications and guidelines for the coir non-woven stitched composite geotextiles made of a layer of bio-degradable coir blanket sandwiched between two layers of polypropylene/high-density polyethylene/low-density polyethylene (PP / HDPE / LDPE) netting used in rainwater or wind erosion control application in slopes of road and railway embankments, mine spoil dumps in hill slopes or earth work and road construction.

1.2 This standard does not apply to other types of erosion control mats made from natural material such as jute, straw and polymer fibers.

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 the standard indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1. Coir non-woven stitched composite geotextiles — Open structure coir non-woven stitched composite geotextiles made out of Coir fibre made in to non-woven matrix with polypropylene/high-density polyethylene/low-density polyethylene (PP/HDPE/LDPE) netting and stitched with mono or multifilament polypropylene/high-density polyethylene/low-density polyethylene yarn together as a homogenized composite geotextile.

3.2 **Mulch —** Mulch refers to any material that would be decomposed fully or partially over a period of time and serving as a nutrient to the vegetation that is being nurtured. The mulch has a short-term role to play and not a long-term role in soil stabilization.

4 TYPES

4.1 Coir non-woven stitched composite geotextiles shall be of the following types based on the mass:

a) *Type I* — Having mass 300 g/m^2;
b) *Type II* — Having mass 450 g/m^2; and
c) *Type II* — Having mass 550 g/m^2.

In addition to above types, specialized coir non-woven stitched composite geotextiles can also be manufactured as per the agreement between the buyer and seller.

4.2 Table 1 shows the types of coir non-woven stitched composite geotextiles and their respective suitability for different slope conditions.

Table 1 Slope Suitability of Coir Non-woven Stitched Composite Geotextile for Different Slope Conditions

(*Clause* 4.2)

Sl No. (1)	**Type of CNWGT** (2)	**GSM** *Min* (3)	**Suitability** (4)
i)	I	300	1H:2V slopes
ii)	II	450	1H:2V slopes and low to medium flow channels
iii)	III	550	1H:1V slopes and medium to high flow channels

5. MANUFACTURE, WORKMANSHIP AND FINISH

5.1 Coir fibre made in non-woven matrix sandwiched between two polypropylene/high-density polyethylene/low-density polyethylene (PP/HDPE/LDPE) netting and all three (bottom netting, coir fibre and top netting) is stitched together with polypropylene/high-density polyethylene/low-density polyethylene (PP/HDPE/LDPE) monofilament or multi filament yarn in the coir stitch blanket making machine. The coir fiber used for manufacturing the CNWGT shall be homogeneously blended and evenly distributed throughout the mat.

5.2 Coir non-woven stitched composite geotextiles shall be stitched using UV stabilized polyester/polypropylene/high density polyethylene monofilament or multi filament yarn. The stitching thread shall have minimum linear density of 700 denier and a minimum tenacity of 5 gpd. The stitching shall be uniform without any loose thread. The distance between two rows of stitches shall not be more that 60 mm with a minimum stitch density of 2 stitches/dm.

6 DIMENSIONS AND TOLERANCE

6.1 The length and width of coir non-woven stitched composite geotextiles shall be as given in Table 2.

Table 2 Length and Width Requirement for Coir Non-Woven Stitched Composite Geotextiles
(*Clause* 6.1)

Sl No. (1)	**Characteristics** (2)	**Requirement** (3)	**Tolerance** Percent (4)
i)	Length, m	20 to 70 or as agreed	+3 -1
ii)	Width, m	1.2 to 5 or as agreed	

7 REQUIREMENT

7.1 The coir non-woven stitched composite geotextiles shall meet the requirements as given in Table 3.

Table 3 Requirements of Coir Non-woven Stitched Composite Geotextiles
(*Clause* 7.1)

Sl No	**Characteristics**	**Requirement (s)**			**Method of test, Ref to**
(1)	(2)	(3)	(4)	(5)	(6)
		Type I	Type II	Type III	
i)	Thickness, mm, *Min* (at 2kPa)	4	5	6	IS 13162 (Part 3)
ii)	Mass per unit area, g/m², *Min*	300	450	550	IS 14716
iii)	Wide width tensile strength (Dry), kN/m, *Min* a) Machine direction b) Cross machine direction	 1.5 1.0	 2.0 1.5	 2.5 2.0	IS 16635
iv)	Elongation at break (Dry), Percent, *Min* a) Machine direction b) Cross machine direction	 20 15	 20 15	 15 15	IS 16635
v)	Water absorption, Percent, *Min*	160	160	160	IS 15868 (Part 4)
vi)	Light Transmittance, Percent, *Min*	16	7	5	Annex C of IS 16008 (Part 1)

7.2 The netting used for coir non-woven stitched composite geotextiles shall meet the requirements as given in Table 4.

Table 4 Requirements for Netting
(*Clause* 7.2)

Sl No.	Characteristic	Requirement	Method of test, Ref to
(1)	(2)	(3)	(4)
i)	Material	Polypropylene/high density polyethylene/low density polyethylene	IS 667
ii)	Mass per unit area, g/m², *Min*	8	IS 14716
iii)	Wide width tensile strength, kN/m, *Min* a) Machine direction b) Cross machine direction	 0.8 0.8	IS 16635
iv)	Elongation at break, percent, *Min* a) Machine direction b) Cross machine direction	 14 15	IS 16635
4	Mesh size, mm	10 to 25	—

7.3 The guidelines for selection and installation of coir non-woven stitched composite geotextiles are given in Annex B. A comprehensive guidance on selecting vegetation species specific to different applications, needs and challenges is given in Annex C. It covers information and recommendations for grasses suitable for soil moisture conservation (SMC) and slope stabilization, species specifically used for nitrogen enrichment in mine areas, and a selection of plant species well-suited for stabilizing overburden dumps and mine pits.

8 SAMPLING AND CRITERIA FOR CONFORMITY

8.1 Lot

The number of rolls of coir non-woven stitched composite geotextiles of the same size, type and quality delivered to a buyer against one dispatch note shall constitute a lot.

8.2 The number of rolls of coir non-woven stitched composite geotextiles to be selected at random shall be according to column 2 and column 4 of Table 5. To ensure the randomness of selection, IS 4905 may be followed.

Table 5 Selection of Rolls for Testing
(*Clauses* 8.2, 8.3 and 8.3.1)

Sl No.	Lot Size (No. of Rolls)	Sample Size (No. of Rolls of Coir non woven stitched composite geotextiles)	Permissible Number of Non-conforming Rolls	Sub-Sample Size
i)	(1)	(2)	(3)	(4)
ii)	Up to 50	3	2	0
iii)	51 to 150	5	0	2
iv)	151 to 300	8	1	3
v)	301 to 500	13	2	5
vi)	501 and above	20	3	5

8.3 Number of Tests and Criteria for Conformity

8.3.1 The conformity of a lot to the requirements of the standard, shall be determined on the basis of the tests carried out on the sample selected from the lot as indicated in Table 6.

Table 6 Number of Tests and Criteria for Conformity

(*Clause* 8.3.1)

Sl No.	Characteristics	Number of Samples	Criteria for Conformity
i)	Length, width, mesh opening, thickness, mass per unit area	According to col 2 of Table 5	All the test pieces shall meet the requirement.
ii)	Breaking strength, material, water absorption, light transmittance	According to col 4 of Table 5	Number of non-conforming pieces shall not exceed the corresponding number given in column 3 of Table 5

9 MARKING AND LABELLING

The rolls of coir non-woven stitched composite geotextiles shall be marked with the following by attaching the printed labels:

i) Manufacturer's name, initials or trademark;
ii) Batch /lot number;
iii) Name of the material with type of the coir non-woven stitched composite geotextiles, that is Type I/Type II/Type III;
iv) Type of netting used for manufacture of coir non-woven stitched composite geotextiles;
v) Month and year of manufacture;
vi) Dimensions (length and width) of coir non-woven stitched composite geotextiles;

vii) The country of origin; and
viii) Any other information/instruction provided by the manufacturer/required under law.

10 PACKING

The coir non-woven stitched composite geotextiles shall be supplied in roll form and each roll shall be packed securely so as to allow normal handling and transport without tearing and exposing the contents. The rolls shall be labeled or tagged to provide product identification sufficient for field identification as well as inventory and quality control purpose. Details of the packing shall be as agreed to between the buyer and the seller.

11 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity 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.

12 STORAGE AND HANDLING

12.1 During storage, rolls of coir non-woven stitched composite geotextiles shall be elevated off the ground and adequately protected against 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^{o} C;
f) Excessive mud, wet concrete, epoxy, or other deleterious materials coming in contact with and affixing to the material;
g) Any other environmental condition that may damage the physical properties.

12.2 The coir non-woven stitched composite geotextiles shall be stored at temperatures above -5^{o} C and below 50^{o} C

12.3 Coir non-woven stitched composite geotextiles shall be stored in a manner which protects them from adverse impact of weather. If stored outdoors, they shall be elevated and protected with an appropriate cover.

12.4 The coir non-woven stitched composite geotextiles rolls shall be laid flat.

ANNEX A
(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*

667 : 1981	Methods for identification of textile fibres (*first revision*)
4905 : 2015	Random sampling and randomization procedures (*first revision*)
13162 (Part 3) : 2021	Geosynthetics — Determination of thickness at specified pressure (part 3) single layers (*first revision*)
14716 : 2021	Geosynthetics — Test method for the determination of mass per unit area of geotextiles and geotextile-related products (*first revision*)
15868 (Part 1 to 6) : 2008	Natural fibre geotextiles (jute geotextile and coir bhoovastra) — Methods of test
16008 : (Part 1) : 2016	Agrotextiles — Shade nets for agriculture and horticulture purposes — Specification (Part 1): shade nets made from tape yarns (*first revision*)
16635 : 2017	Geosynthetics — Wide-width tensile test

ANNEX B
(*Clause* 7.3)

B-1 GUIDELINES FOR SELECTION AND INSTALLATION OF COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES

B-1.1 SELECTION OF COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES

The choices of coir non-woven stitched composite geotextiles basically depend on the type of soil to be protected. It requires to be ensured primarily that the slope to be protected from rainwater erosion is geo-technically stable. It also required considering the extreme rainfall in a limited time span at that location as the intensity of rainfall is more important than the average annual rain fall. It is recommended that the choice of coir non-woven stitched composite geotextiles should be limited to Type I coir non-woven stitched composite geotextiles, where intensity of rainfall and surface wind are mild irrespective of type soil and slope is <1:1.

B-2 INSTALLATION METHOD OF COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES IN SURFACE EROSION CONTROL IN ROAD AND RAILWAY EMBANKMENTS AND HILL SLOPES.

B- 2.1 The stages of laying of woven coir non-woven stitched composite geotextiles on slopes for rain water or surface wind erosion control are as under.

B-2.1.1 The slope should be made free from undulations, soil slurry, mud and sharp projections and compacted with additional earth where necessary.

B-2.1.2 Anchoring trenches should be excavated at the top and toe of the slope (300 mm x 300 mm). The top trench should be sufficiently away from the edge of the slope considering the stability of the slope.

B-2.1.3 The selected coir non-woven stitched composite geotextiles should be unrolled across the top trench and along the slope downward, caring to see that it touches the soil surface at all points.

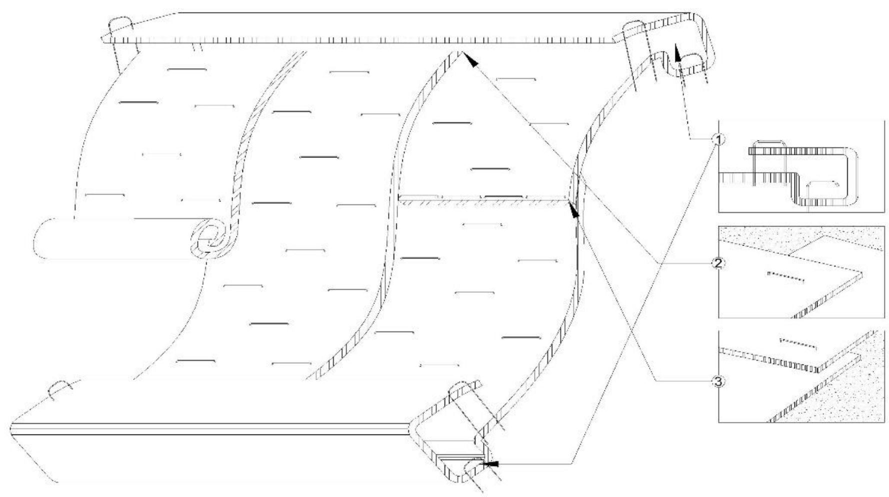


FIG. 1 LAYING METHOD FOR COIR NON-WOVEN STITCHED COMPOSITE GEO-TEXTILES AND PIN POSITION

B-2.1.4 Overlaps should be minimum 300 mm at sides and ends (*see* Fig. 1). The coir non-woven stitched composite geotextiles at the higher level on the slope should be placed over level. Side overlaps of a coir non-woven stitched composite geotextiles piece should be placed over its next piece on one side and under the next piece on the other.

B-2.1.5 The coir non-woven stitched composite geotextiles should be fixed in position by steel staples (usually of 11 gauge diameter, and minimum 300 mm of length of penetration) as shown in the Fig. 2 or by spilt bamboo pegs. Stapling should be done normally at an interval of 1000 mm both in longitudinal and transverse directions. Special care should be taken to staple the coir non-woven stitched composite geotextiles within the anchoring trenches both at the bottom and at the sides (*see* Fig 1 and Fig.2)

B-2.1.6 The anchoring trenches should be filled up with brick-bats/soil for preventing displacement of the coir non-woven stitched composite geotextiles. Care should be taken that the overlaps are not displaced during installation.

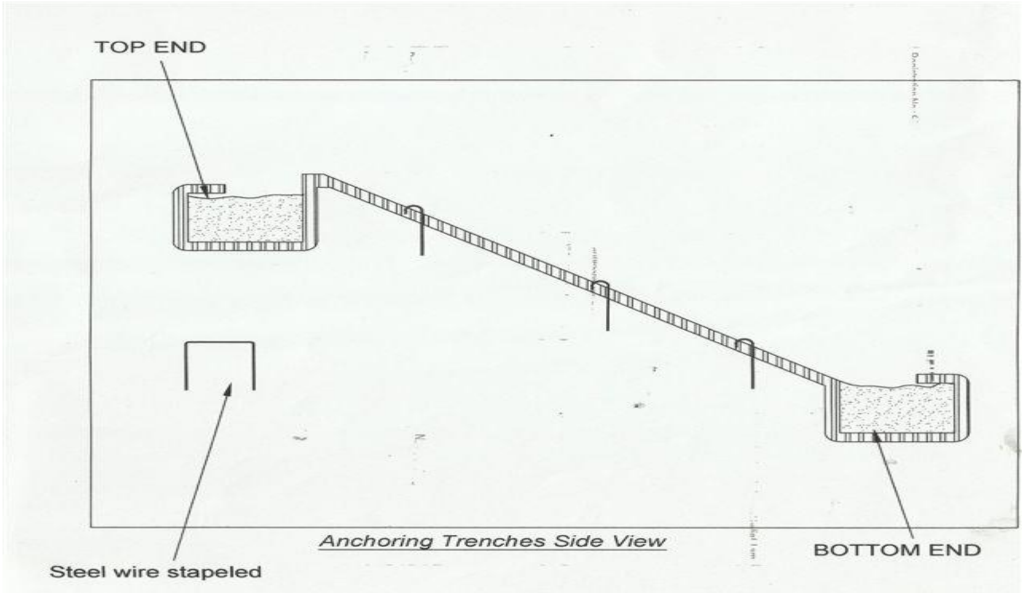


FIG.2 STAPLING OR PEG INSERTION

B-2.1.7 Care should be taken to ensure that the coir non-woven stitched composite geotextiles are not damaged due to puncture, tear and other operational stresses.

B-2.1.8 Seeds of vegetation (grass, legumes etc., of appropriate variety, preferably local vegetation) should then be spread (refer to Annex B for guidance in selecting the species of vegetation and refer to Annex C for recommended grasses, plants and trees). If seeds are not available, saplings of the appropriate plant species may be planted at suitable intervals through the opening of the coir non-woven stitched composite geotextiles. Hydro seeding with seeds can also be adopted.

B-2.1.9 In special circumstances, a second dose of seeds may be spread with dibbling of locally available grass.

B-2.1.10 Installation should be completed preferably before the monsoon to take advantage of the rains for quick germination of seeds.

B-3 INSTALLATION METHOD OF COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES IN SURFACE EROSION CONTROL IN MINE SPOIL DUMPS

B-3.1 The stages of laying of coir non-woven stitched composite geotextiles in water/surface wind erosion control in mine spoil dumps are as under

B-3.1.1 The slope should be made free from undulations, soil slurry, mud and sharp projections and compacted with additional earth where necessary.

B-3.1.2 Anchoring trenches should be excavated at the top and toe of the slope (of size minimum 300 mm^2). The top trench should be minimum 2 meter away from the edge of the slope.

B-3.1.3 The selected coir non-woven stitched composite geotextiles should be unrolled across the top trench and along the slope downward, caring to see that it touches the soil surface at all points.

B-3.1.4 Overlaps should be minimum 300 mm at sides and ends (*see* Fig 3). The coir non-woven stitched composite geotextiles at the higher level on the slope should be placed over level. Side overlaps of a coir non-woven stitched composite geotextiles piece should be placed over its next piece on one side and under the next piece on the other.

B-3.1.5 The coir non-woven stitched composite geotextiles should be fixed in position by steel staples as shown in the Fig.2 (usually of 11 gauge diameter and minimum 300 mm penetration) or by spilt bamboo pegs. Stapling should be done normally at an interval of 1000 mm both in longitudinal and transverse directions. Special care should be taken to staple the coir non-woven stitched composite geotextiles both at the bottom and at the sides (*see* Fig 3).

B-3.1.6 The anchoring trenches should be filled up with brick-bats/soil for preventing displacement of the coir non-woven stitched composite geotextiles. Care should be taken that the overlaps are not displaced during installation.

B-3.1.7 Care should be taken to ensure that the coir non-woven stitched composite geotextiles are not damaged due to puncture, tear and other operational stresses.

B-3.1.8 Seeds of vegetation (grass, legumes, etc. of appropriate variety, preferably locally available) should then be spread (refer to Annex B for guidance in selecting the species of vegetation and refer to Annex C, D and E for recommended grasses, plants and trees). If seeds are not available, saplings of the appropriate plant species may be planted at suitable intervals through the opening of the coir non-woven stitched composite geotextiles.

B-3.1.9 In special circumstances, a second dose of seeds may be spread with dibbling of locally available grass.

B-3.1.10 Proper wetting has to be done for the germination of the seeds or saplings.

B-4 MONITORING

B-4.1 Close monitoring should be done for at least one season cycle.

B-4.2 The treated area should be kept out of bounds for cattle and other grazing animals till the time of maturity of vegetation.

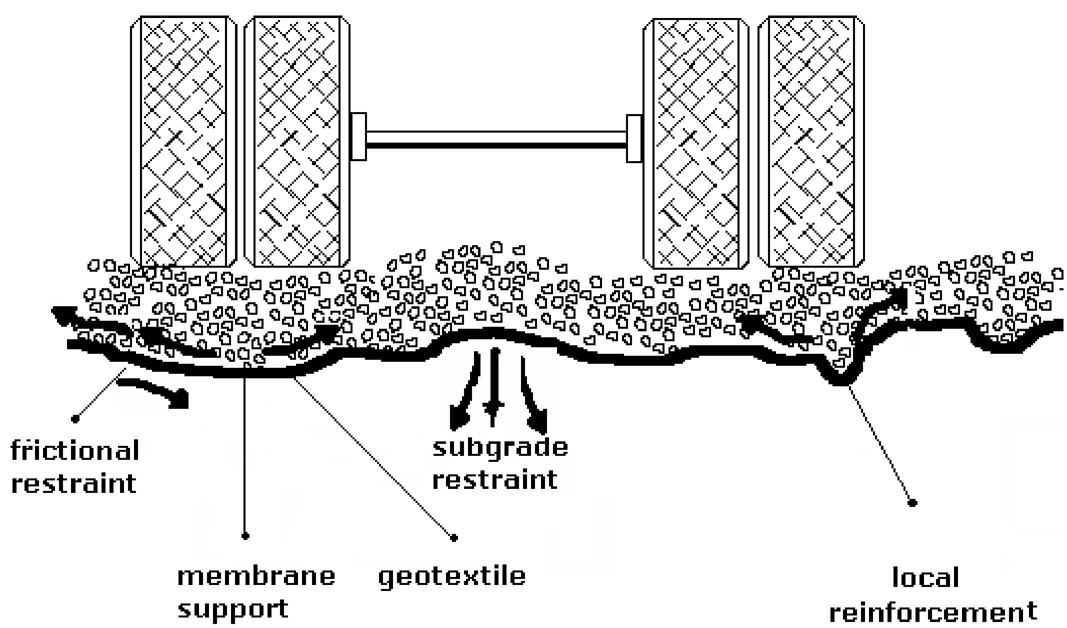
B-4.3 The damage and displacement of coir non-woven stitched composite geotextiles should be noted for corrective action. Torn portions of the coir non-woven stitched composite geotextiles should be covered with new pieces of coir non-woven stitched composite geotextiles of identical specification duly stapled at all sides.

B-4.4 Watering/maintenance of identical specifications duly stapled at all sides.

B-4.5 Advice should be sought from specialist to find out cause of unsatisfactory growth of vegetation. The advice should be implemented. Withered plants should be replaced. Species of vegetation needs to be selected carefully considering the local soil and climatic conditions.

B-5 INSTALLATION METHOD OF COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES IN EARTH WORK AND ROAD CONSTRUCTION

B-5.1 Unpaved roads are used as a temporary or permanent access depending upon conditions. Coir non-woven stitched composite geotextiles will be an ideal geotextile for the unpaved roads. In order for a coir non-woven stitched composite geotextile to perform beneficially in road stabilization applications the fabric must not only be properly designed it must be properly installed, must be cleared of sharp objects, which could puncture the geo-textiles. Nonwoven stitched composite geotextile damaged during placement, or installed in a highly wrinkled condition will not perform. Nonwoven stitched composite geotextile maintain integrity during the course of its life. The aggregate overlay must be placed to its full design depth, and it must apply in a manner that will not cause damage to nonwoven stitched composite geotextile from movement of construction equipment. The main functions of the coir nonwoven stitched composite geotextile in unpaved road application are separation, filtration/drainage and reinforcement



B-5.2 INSTALLATION

B-5.2.1 The area over which the coir non-woven stitched composite geotextiles is to be placed must be cleared sharp objects, tree stumps or large stones that could puncture coir non woven stitched composite geotextiles. The area should be excavated, stripping away soft soil or unsuitable base materials, then compacted to design grade.

B-5.2.2 The coir non-woven stitched composite geotextile is unrolled on to the prepared sub-grade in the direction that aggregate will be placed. The coir non-woven stitched composite geotextiles sections must be overlapped side-to-side and end-to-end around 450mm. The edges of coir non-woven stitched composite geotextiles should slope towards drainage ditches or other drain systems that parallel the roadway. Granular material can now be back dumped on to the coir non-woven stitched composite geotextiles beginning on firm ground just in front of the coir non-woven stitched composite geotextiles.

B-5.2.3 The aggregate is then spread to a thickness sufficient to allow subsequent compaction. Initial compaction can be accomplished and then fully compacted. Ruts must not be graded down; rather, they should be filled with additional aggregate and compacted.

B-6.3 SELECTION OF COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES

B-6.3.1 The choices of coir non-woven stitched composite geotextiles basically depend on the type of pavement to be protected. It is recommended that the choice coir non-woven stitched composite geotextiles should be limited to Type II.

ANNEX C

(*Clause* 7.3)

GUIDANCE IN SELECTING THE SPECIES OF VEGETATION

The vegetation species for their use in different soil types, specific site conditions are listed in the following table:

Sl No.	*Name of the species*	*Suited for*
1	Chrysopogon zizanioides (khus - khus)	All type of soil
2	Avicennia officinalis	Shrub suitable for marshy places
3	Rhizophora Mucrunata	Shrub suitable for marshy places
4	Cyperus Exaltatus	Grass suitable for highway slopes
5	Acrostichum Aureum	Shrub suitable for dam sites
6	Adiantum spices	Shrub suitable for dam sites
7	Cyanodon dactylon	For light sandy soils
8	Cenehurs ciliaries	For most types of soil
9	Eragrostis curuvla	For protecting terraces and channels
10	Dianthum annulatum	For light soil
11	Pennisetum pedicellatum	Sandy loam soil
12	Both rochola glabra	For red semi arid soil
13	Stylosanthis gracilis	For light soils with low moisture
14	Stylosamthis gusineusis	For light and medium soil with low moisture
15	Pucraria hirsute	Cover crop suited to alluvial soil and For hills in humid climate
16	Pennisetum purpureum	For hill slopes
17	Peuraria hirsta	Cover crop suited to alluvial soil

GRASSES RECOMMENDED FOR SOIL MOISTURE CONSERVATION (SMC) AND SLOPE STABILIZATION

The grass species recommended for their use and effectiveness in soil moisture conservation (SMC) and slope stabilization are listed in the following table:

Sl No.	*Species*	*Propagation method*
1	*Bambusa arundinacea*	Rhizome/Seeds
2	*Bothriochloa pertusa*	Seeds
3	*Chrysopogon fulvus*	Slips
4	*Cymbopogon citratus*	Slips/Seeds
5	*Cymbopogon flexuosus*	Slips
6	*Cymbopogon martini*	Slips
7	*Cymbopogon nardus*	Slips
8	Chrysopogon zizanioides (khus - khus)	Slips
9	*Cynodon dactylon*	Rhizome/Seeds
10	*Dendrocalamus strictus*	Rhizome
11	*Dichanthium annulatum*	Seeds
12	*Eleusine indica*	Slips/Seeds
13	*Heteropogon contortus*	Slips/Seeds
14	*Pennisetum pedicillatum*	Seeds
15	*Saccharum spontaneum*	Slips

SPECIES RECOMMENDED FOR NITROGEN ENRICHMENT OF MINE AREAS

The vegetation species which are recommended for nitrogen enrichment of mine areas based on their ability to improve soil fertility and promote ecological restoration in these challenging environments are listed in the following table:

Sl No.	*Species*	*Family*	*Habit*
1	*Cassia auriculata*	Caesalpiniaceae	Shrub
2	*Cassia hirsuta*	Caesalpiniaceae	Shrub
3	*Cassia mimosoides*	Caesalpiniaceae	Herb
4	*Cassia occidentalis*	Caesalpiniaceae	Herb
5	*Cassia tora*	Caesalpiniaceae	Herb
6	*Crotalaria albida*	Fabaceae	Herb
7	*Crotalaria juncea*	Fabaceae	Herb
8	*Crotalaria retusa*	Fabaceae	Herb
9	*Crotalaria verrucosa*	Fabaceae	Herb
10	*Indigofera cassioides*	Fabaceae	Shrub
11	*Mimosa pudica*	Mimosaceae	Herb

12	*Stylosanthes fruticosa*	Fabaceae	Herb
13	*Tephrosia purpurea*	Fabaceae	Herb
14	*Tephrosia villosa*	Fabaceae	Herb

PLANT SPECIES SUITABLE FOR OVER BURDEN DUMP AND MINE PIT STABILIZATION

Plant species suitable for overburden dump and mine pit stabilization, prevent erosion and restore ecological balance in disturbed mining areas. The list of such species is given in the following table:

Sl No.	*Plant species*	*Family*	*Habit*
1	*Acacia catechu*	Mimosaceae	Tree
2	*Acacia chundra*	Mimosaceae	Tree
3	*Acacia nilotica*	Mimosaceae	Tree
4	*Aegle marmelos*	Rutaceae	Tree
5	*Agave Americana*	Agavaceae	Shrub
6	*Agave sisalana*	Agavaceae	Shrub
7	*Albizia lebbeck*	Mimosaceae	Tree
8	*Albizia odoratissima*	Mimosaceae	Tree
9	*Albizia procera*	Mimosaceae	Tree
10	*Annona squamosa*	Annonaceae	Tree
11	*Anogeissus latifolia*	Combretaceae	Tree
12	*Azadirachta indica*	Meliaceae	Tree
13	*Bauhinia racemosa*	Caesalpiniaceae	Tree
14	*Boswellia serrata*	Burseraceae	tree
15	*Bothriochloa pertusa*	Poaceae	Herb
16	*Calotropis gigantean*	Asclepiadaceae	Shrub
17	*Calotropis procera*	Asclepiadaceae	Shrub
18	*Cassia auriculata*	Caesalpiniaceae	Shrub
19	*Cassia fistula*	Caesalpiniaceae	Tree
20	*Chloroxylon swietenia*	Flindersiaceae	Tree
21	*Chrysopogon fulvus*	Poaceae	Herb
22	*Cymbopogon flexuosus*	Poaceae	Herb
23	*Cymbopogon martini*	Poaceae	Herb
24	*Cymbopogon nardus*	Poaceae	Herb
25	*Dalbergia latifolia*	Fabaceae	Tree
26	*Dalbergia sissoo*	Fabaceae	Tree
27	*Dendrocalamus strictus*	Poaceae	Shrub
28	*Dichanthium annulatum*	Poaceae	Herb

29	*Diospyros melanoxylon*	Ebenaceae	Tree
30	*Dodonaea viscosa*	Sapindaceae	Shrub
31	*Dolichandrone atrovirens*	Bignoniaceae	Tree
32	*Eleusine indica*	Poaceae	Herb
33	*Ficus racemosa*	Moraceae	Tree
34	*Ficus religiosa*	Moraceae	Tree
35	*Garuga pinnata*	Burseraceae	Tree
36	*Givotia rottleriformis*	Euphorbiaceae	Tree
37	*Gmelina arborea*	Verbenaceae	Tree
38	*Grewia tiliifolia*	Tiliaceae	Tree
39	*Haldina cordifolia*	Rubiaceae	Tree
40	*Hardwickia binata*	Caesalpiniaceae	Tree
41	*Heteropogon contortus*	Poaceae	Herb
42	*Holoptelea integrifolia*	Ulmaceae	Tree
43	*Lagerstroemia parviflora*	Lythraceae	Tree
44	*Limonia acidissima*	Rutaceae	Tree
45	*Madhuca longifolia var latifolia*	Sapotaceae	Tree
46	*Melia dubia*	Meliaceae	Tree
47	*Mitragyna parvifolia*	Rubiaceae	Tree
48	*Morinda pubescens*	Rubiaceae	Tree
49	*Pennisetum pedicillatum*	Poaceae	Herb
50	*Phyllanthus emblica*	Euphorbiaceae	Tree
51	*Pithecelobium dulce*	Mimosaceae	Tree
52	*Pongamia pinnata*	Fabaceae	Tree
53	*Pterocarpus marsupium*	Fabaceae	Tree
54	*Saccharum spontaneum*	Poaceae	Herb
55	*Santalam album*	Santalaceae	Tree
56	*Sehima nervosum*	Poaceae	Herb
57	*Soymida febrifuga*	Meliaceae	Tree
58	*Stereospermum personatum*	Bignoniaceae	Tree
59	*Stylosanthes hamata*	Fabaceae	Herb
60	*Tamarindus indica*	Caesalpiniaceae	Tree
61	*Tecoma stans*	Bignoniaceae	Tree
62	*Terminalia bellirica*	Combretaceae	Tree
63	*Terminalia chebula*	Combretaceae	Tree
64	*Vitex negundo*	Verbenaceae	Shrub
65	*Wrightia tinctoria*	Rubiaceae	Tree
66	*Ziziphus mauritiana*	Rhamnaceae	Tree

ANNEX 5
(*Item* 5.1)

COMMENTS RECEIVED FROM SHRI PRADIP KUMAR CHOUDHARY, IN PERSONAL CAPACITY ON ‘TEXTILES — COIR NON-WOVEN STITCHED COMPOSITE GEOTEXTILES FOR EROSION CONTROL APPLICATIONS — SPECIFICATION’

Commentator: Shri Pradip Kumar Choudhary, In Personal Capacity

Comment:

Item, Clause Sub-Clause No. Commented upon (Use Separate Box afresh)	Comments	Specific Proposal (Draft clause to be add/amended)	Remarks	Technical References on which (2), (3), (4) are based
(1)	(2)	(3)	(4)	(5)
B-2 Installation method of CNWGT	B- 2.1 The stages of laying of *woven coir non-woven* stitched composite geotextiles- this term is confusing	The word “woven” should be deleted		
B-5 Road Construction	Table 3, No- iii) Tensile strength shown in Table 3 appears to be inadequate		Expert opinion from geotechnical engineer may be sought for	

The draft specifications in all other respect appears to be in order

ANNEX 6
(*Item* 5.2)

WIDE CIRCULATION DRAFTS

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDRADS

Draft For Comments Only Doc: TXD 30 (26515) WC
September 2024

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भारतीय मानक मसौदा

भूवस्त्रादि और भूवस्त्रादि संबंधित उत्पाद — आंतरिक संरचनात्मक संधि-स्थलों का सामर्थ्य भाग 2 जियोकंपोज़िट्स

[आई एस 17369 (भाग 2) : 2020 *का पहला पुनरीक्षण]*

Draft Indian Standard

Geotextiles and Geotextile-related Products — Strength of Internal Structural Junctions Part 2 Geo-composites

[First Revision of IS 17369 (Part 2) : 2020 *]*

ICS: 59.080.70

Geosynthetics Sectional Committee , TXD 30	Last date for receipt of comments is 16 October 2024

NATIONAL FOREWORD

(*Formal clauses will be added later*)
This Indian Standard intended to be adopted is identical with ISO 13426-2:2024 'Geotextiles and geotextile-related products — Strength of internal structural junctions — Part 2: Geocomposites ' issued by the International Organization for Standardization (ISO).

The standard was originally published in 2020. The second revision of the standard has been undertaken to align it with the latest version of ISO 13426-2 : 2024. The major changes in this revision are as follows:

— In Clause 9, the calculation of the junction strength for tests with multiple peaks has been modified.

Since, ISO 13426 has been published in two parts, this standard has also been published in two parts. Other part is as under:

Part 1 Geocells

Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words ‘International Standard’ appear referring to this standard, they should be read as ‘Indian Standard’.
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In the standard intended to be adopted, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 7500-1 Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system	IS 1828 (Part 1) : 2022 Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system (*fifth revision*)	Identical with ISO 7500-1 : 2018
ISO 9862 Geosynthetics — Sampling and preparation of test specimens	IS 14706 : 1999 Geotextiles — Sampling and preparation of test specimens	Technically equivalent
ISO 10318-1 Geosynthetics — Part 1: Terms and definitions	IS 13321 (Part 1) : 2022 Geosynthetics — Part 1 terms and definitions (*first revision*)	Identical with ISO 10318-1 : 2015

The technical committee has reviewed the provisions of the following International Standards referred in this standard intended to be adopted and has decided that these are acceptable for use in conjunction with this standard:

International Standard	*Title*
ISO 554	Standard atmospheres for conditioning and/or testing — Specifications

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'.

Extract of ISO 13426-2:2024 'Geotextiles and geotextile-related products — Strength of internal structural junctions Part 2 : Geocomposite'

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.
Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 221 *Geosynthetics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 189, *Geotextiles and geotextile-related products,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 13426-2:2005), which has been technically revised.

The main changes are as follows:

- — In Clause 9, the calculation of the junction strength for tests with multiple peaks has been modified.

A list of all parts in the ISO 13426 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

1 Scope

This document describes index tests for determining the strength of the internal structural junctions under different loading conditions of all geocomposites and of clay geosynthetic barriers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*
- ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*
- ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*
- ISO 10318-1, *Geosynthetics — Part 1: Terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10318-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- — ISO Online browsing platform: available at https://www.iso.org/obp
- — IEC Electropedia: available at https://www.electropedia.org/

3.1 failure

Point at which a geosynthetic ceases to be functionally capable of its intended use
Note 1 to entry: A material can be considered to have failed without rupture.

3.2 geocomposite

Manufactured, assembled material using at least one geosynthetic product among the components, used in contact with soil and/or other materials in geotechnical and civil engineering applications

3.3 junction

Point or line where two of the geosynthetics components are connected

3.4 junction strength

Peak load attained during the test, reported to the unit width of the product
Note 1 to entry: The junction strength is expressed in kilonewtons per metre (kN/m).

3.5 peel test

Tensile test where two components of a *geocomposite* (3.2) are separately clamped and one component is peeled away from the other

3.6 rupture

Breaking or tearing apart of a geosynthetic

3.7 shear test

Tensile test where two components of a *geocomposite* (3.2) are separately clamped and the *failure* (3.1) occurs along the plane of the product

भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDRADS

<u>*Draft For Comments Only*</u> Doc: TXD 30 (26517) WC
September 2024

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मृदा सुदृढ़ीकरण के लिए भूकृत्रिम की दीर्घकालिक शक्ति की निर्धारण के लिए दिशानिर्देश

(आई एस 17365 : 2020 *का पहला पुनरीक्षण)*

Draft Indian Standard

Guidelines for the Determination of the Long-term Strength of Geosynthetics for Soil Reinforcement

(First Revision of IS 17365 : 2020 *)*

ICS : 59.080.70

Geosynthetics Sectional Committee , TXD 30	Last date for receipt of comments is 16 October 2024

NATIONAL FOREWORD

(*Formal clauses will be added later*)

This Indian Standard intended to be adopted is identical with ISO/TS 20432 : 2022(en) 'Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement ' issued by the International Organization for Standardization (ISO).

The standard was originally published in 2020. The first revision of the standard has been undertaken to align it with the latest version of ISO/TS 20432 : 2022. The major changes in this revision are as follows:

— Subclause 7.4 has been modified to further detail and clarify the fitting of linear regression curves to time-temperature block shifted creep-rupture test results.

Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In the standard intended to be adopted, reference appears to certain International Standard for which Indian Standard also exist. The corresponding Indian Standard which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 10318-1 Geosynthetics — Part 1: Terms and definitions	IS 13321 (Part 1) : 2022 Geosynthetics part 1 terms and definitions (*first revision*)	Identical with ISO 10318-1 : 2015

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'.

Extract of ISO/TS 20432:2022(en) 'Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement'

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 221, *Geosynthetics.*

This first edition of ISO/TS 20432 cancels and replaces ISO/TR 20432:2007, which has been technically revised. It also incorporates the Technical Corrigendum ISO/TR 20432:2007/Cor 1:2008.

The main changes are as follows:

- — Subclause 7.4 has been modified to further detail and clarify the fitting of linear regression curves to time-temperature block shifted creep-rupture test results.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

1 Scope

This document provides guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement.

This document describes a method of deriving reduction factors for geosynthetic soil-reinforcement materials to account for creep and creep rupture, installation damage and weathering, and chemical and biological degradation. It is intended to provide a link between the test data and the codes for construction with reinforced soil.

The geosynthetics covered in this document include those whose primary purpose is reinforcement, such as geogrids, woven geotextiles and strips, where the reinforcing component is made from polyester (polyethylene terephthalate), polypropylene, high density polyethylene, polyvinyl alcohol, aramids and polyamides 6 and 6,6. This document does not cover the strength of joints or welds between geosynthetics, nor whether these might be more or less durable than the basic material. Nor does it apply to geomembranes, for example, in landfills. It does not cover the effects of dynamic loading. It does not consider any change in mechanical properties due to soil temperatures below 0 °C, nor the effect of frozen soil. The document does not cover uncertainty in the design of the reinforced soil structure, nor the human or economic consequences of failure.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ISO 10318-1, *Geosynthetics — Part 1: Terms and definitions*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10318-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- — ISO Online browsing platform: available at https://www.iso.org/obp
- — IEC Electropedia: available at https://www.electropedia.org/

3.1.1 long-term strength

Load which, if applied continuously to the geosynthetic during the service lifetime, is predicted to lead to rupture at the end of that lifetime

3.1.2 reduction factor

Factor (≥ 1) by which the tensile strength is divided to take into account particular service conditions in order to derive the long-term strength

Note 1 to entry: In Europe, the term 'partial factor' is used.

3.1.3 characteristic strength

95 % (two-sided) lower confidence limit for the tensile strength of the geosynthetic, approximately equal to the mean strength less two standard deviations

Note 1 to entry: This should be assured by the manufacturer’s own quality assurance scheme or by independent assessment.

3.1.4 block shifting

Procedure by which a set of data relating applied load to the logarithm of time to rupture, all measured at a single temperature, are shifted along the log time axis by a single factor to coincide with a second set measured at a second temperature

3.1.5 product line

Series of products manufactured using the same polymer, in which the polymer for all products in the line comes from the same source, the manufacturing process is the same for all products in the line, and the only difference is in the product mass per area or number of fibres contained in each reinforcement element

3.2 Abbreviated terms

CEG	carboxyl end group
DSC	differential scanning calorimetry
HALS	hindered amine light stabilizers
HDPE	high density polyethylene
HPOIT	high pressure oxidation induction time
LCL	lower confidence limit
MARV	minimum average roll value
OIT	oxidation induction time
PA	polyamide
PET	polyethylene terephthalate
PP	polypropylene
PTFE	polytetrafluorethylene
PVA	polyvinyl alcohol
SIM	stepped isothermal method
TTS	time-temperature shifting

3.3 Symbols

A_i	time-temperature shift factor
b_a	gradient of Arrhenius graph

d_{50}	mean granular size of fill
d_{90}	granular size of fill for 90 % pass (10 % retention)
f_s	factor of safety
G, H	parameters used in the validation of temperature shift linearity (see 7.4)
m	gradient of line fitted to creep rupture points (log time against load); inverse of gradient of conventional plot of load against log time.
M_n	number averaged molecular weight
n	number of creep rupture or Arrhenius points
P	applied load
R_1	ratio representing the uncertainty due to extrapolation
R_2	ratio representing the uncertainty in strength derived from Arrhenius testing
$f_{R,CH}$	reduction factor to allow for chemical and biological effects
$f_{R,CR}$	reduction factor to allow for the effect of sustained static load
$f_{R,ID}$	reduction factor to allow for the effect of mechanical damage
$f_{R,W}$	reduction factor to allow for weathering
S_{sq}	sum of squares of difference of log (time to rupture) and straight line fit
S_{xx}, S_{xy}, S_{yy}	sums of squares as defined in derivation of regression lines in 9.4.3
σ_0	standard deviation used in calculation of LCL
t	time, expressed in hours
t_{90}	time to 90 % retained strength
t_D	design life
t_{deg}	degradation time during oxidation
t_{ind}	induction time during oxidation
t_{LCL}	LCL of time to a defined retained strength at the service temperature
t_{max}	longest observed time to creep rupture, expressed in hours
t_{n-2}	Student's t for $n - 2$ degrees of freedom and a stated probability
t_R	time to rupture, expressed in hours
t_s	time to a defined retained strength at the service temperature
T	load per width
T_B	batch tensile strength (per width)
T_{char}	characteristic strength (per width) (see 6.1)
T_x	unfactored long-term strength (see 9.4.3)
T_D	long-term strength per width (including factor of safety)
T_{DR}	residual strength
θ_j	temperature of accelerated creep test
θ_k	absolute temperature
T_{LCL}	LCL of T_{char} due to chemical degradation
θ_s	service temperature
x	abscissa: on a creep rupture graph the logarithm of time, in hours
$\bar{x}$	mean value of x
x_i	abscissa of an individual creep rupture point
x_p	predicted time to rupture
y	ordinate: on a creep rupture graph, applied load expressed as a percentage of tensile strength, or a function of applied load

y_0 value of y at 1 h (lg t = 0)
$\bar{y}$ mean value of y
y_i ordinate of an individual creep rupture point
y_0 value of y at time 0, derived from the line fitted to creep rupture points

भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDRADS

Draft For Comments Only Doc: TXD 30 (26521) WC
September 2024

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भारतीय मानक मसौदा

भूवस्त्रादि और भूवस्त्रादि से संबंधित उत्पाद – अपने समधरातल में जल प्रवाह क्षमता का निर्धारण

भाग 2: प्रदर्शन परीक्षण

(आई एस 17179 : 2019 *का पहला पुनरीक्षण)*

Draft Indian Standard

Geotextiles and Geotextile-related Products — Determination of Water Flow Capacity in their Plane
Part 2: Performance Test

(First Revision of IS 17179 : 2019 *)*

ICS : 59.080.70

Geosynthetics Sectional Committee, TXD 30	Last date for receipt of comments is 16 October 2024

NATIONAL FOREWORD

(Formal clauses will be added later)
This Indian Standard intended to be adopted is identical with ISO 12958-2 : 2020 Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 2: Performance test' issued by the International Organization for Standardization (ISO).

The standard was originally published in 2019. The second revision of the standard has been undertaken to align it with the latest version of ISO 12958-2 : 2020.

Since, ISO 12958 has been published in two parts, this standard has also been published in two parts. Other part is as under:

Part 1 Index test

Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
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In the standard intended to be adopted, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 9863-1 Geosynthetics — Determination of thickness at specified pressures Part 1: Single layers	IS 13162 (Part 3) : 2021 Geosynthetics — Determination of thickness at specified pressures Part 3 : Single layers	Identical with ISO 9863-1 : 2016
ISO 10318-1 Geosynthetics Part 1: Terms and definitions	IS 13321 (Part 1) : 2022 Geosynthetics — (Part 1) : Terms and definitions (*first revision*)	Identical with ISO 10318-1 : 2015
ISO 9862 Geosynthetics — Sampling and preparation of test specimens	IS 14706 : 1999 Geotextiles — Sampling and preparation of test specimens	Technically equivalent

The technical committee has reviewed the provisions of the following International Standards referred in this standard intended to be adopted and has decided that these are acceptable for use in conjunction with this standard:

International Standard	*Title*
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	and tests relating to means and variances
ISO 5813	Water quality — Determination of dissolved oxygen — Iodometric method

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.

Extract of ISO 12958-2 : 2020 ‘Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 2: Performance test’

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This document was prepared by Technical Committee ISO/TC 221, *Geosynthetics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 189, *Geosynthetics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 12958-2, together with ISO 12958-1, cancels and replaces ISO 12958:2010, which has been technically revised.

A list of all parts in the ISO 12958 series can be found on the ISO website.

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Introduction

The results obtained under this test procedure do not compare with those obtained under ISO 12958-1, even if some of the test conditions are similar.

Many geosynthetic products can creep under constant load, i.e. see their thickness diminish over time, which can influence their in-plane water flow capacity. Although a seating time typically greater than the one used in ISO 12958-1 is used, this test does not cover all creep-related issues for drainage geo-composites. Assessment of long-term flow capacity involves further considerations.

This procedure can be useful to assess the effect of geotextile intrusion into the drainage core on the transmissivity of a drainage product, using soil from a particular project as a stress-distribution layer in contact with the geotextile.

Other test methods can be more suitable for the characterization of particular drainage products, such as ISO 18325 for prefabricated vertical drains. It is the responsibility of the user to assess the limit of this test procedure and select the appropriate test method, test conditions or both that adequately reflect the particular needs for their project.

In this test method, the flow capacity of the product in a given direction is evaluated considering soil confinement, service load and service hydraulic gradient, as well as primary creep. However:

- — For some products and designs, ensuring the product performance may require controlling the flow capacity of the product in both directions, for example for products with discrete draining elements, where the flow capacity significantly depends on the direction of flow. For these situations, the test shall be performed in both directions.

- — Other field-related issues affect material long-term performance, such as secondary or tertiary creep, chemical or biological clogging, chemical resistance and durability, installation and backfilling. These issues are covered in separate standards and it is essential that they be considered while designing with geosynthetics.

1 Scope

This document specifies a method for determining the constant-head water flow capacity within the plane of a geotextile or geotextile-related product, using boundary materials and test conditions of interest. A standard series of test conditions are proposed, involving soil confinement, low hydraulic gradients, seating times and an array of normal loads.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ISO 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*
- ISO 5813, *Water quality — Determination of dissolved oxygen — Iodometric method*
- ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*
- ISO 9863-1, *Geosynthetics — Determination of thickness at specified pressures — Part 1: Single layers*
- ISO 10318-1, *Geosynthetics — Part 1: Terms and definitions*

3 Terms and definitions

For the purposes of this document, terms and definitions in ISO 10318-1 and the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- — ISO Online browsing platform: available at https://www.iso.org/obp
- — IEC Electropedia: available at http://www.electropedia.org/

3.1 normal compressive stress

Σ

Compressive stress normal to the plane of the geotextile or geotextile-related product, expressed in kilopascals [kPa]

3.2 in-plane flow

Q

Fluid flow within the geotextile or geotextile-related product and parallel to its plane, expressed in litres per second [l/s]

3.3 performance in-plane water flow capacity

$q_{p\ perf\ (\sigma,i,t,b)}$

Volumetric flow rate of water per unit width of specimen at a defined normal compressive stress (*σ*), hydraulic gradient (*i*), seating time (*t*) and boundary conditions (*b*), expressed in litres per second per meter [(l/s)/m]

3.4 hydraulic gradient

i

Ratio of the head loss in the geotextile or geotextile-related product specimen to the distance between two measuring points within the geotextile or geotextile-related product
Note 1 to entry: ISO/TR 18228-4[1] provides information on the significance of the hydraulic gradient.

3.5 seating time

Period of time during which the product is maintained under constant compressive stress before a measurement is made, expressed in hours (h)

3.6 boundary conditions

B

Type of materials contacting the specimen on its external faces
Note 1 to entry: Materials may be soil or granular materials, concrete or rigid platen, or any material likely to be in contact with the geotextile or geotextile-related product.

3.7 geotextile intrusion

Effect of the external loads pushing the geotextile into the draining core of the geocomposite, reducing the flow area, on a geocomposite where a geotextile is combined with a draining core.

भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDRADS

Draft For Comments Only — Doc: TXD 30 (26520) WC
September 2024

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भारतीय मानक मसौदा **भूवस्त्रादि और भूवस्त्रादि से संबंधित उत्पाद – अपने समधरातल में जल प्रवाह क्षमता का निर्धारण**

भाग 1 : सूचकांक परीक्षण

(आई एस 17179 : 2019 *का पहला पुनरीक्षण)*

Draft Indian Standard

Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 1: Index test

(First Revision of IS 17179 : 2019 *)*

ICS : 59.080.70

Geosynthetics Sectional Committee, TXD 30 — Last date for receipt of comments is 16 October 2024

FOREWORD

(*Formal clauses will be added later*)

This Indian Standard intended to be adopted is identical with ISO 12958-1:2020 ‘Geotextiles and geotextile-related products — Determination of water flow capacity in their plane — Part 1: Index test’ issued by the International Organization for Standardization (ISO).

The standard was originally published in 2019. The second revision of the standard has been undertaken to align it with the latest version of ISO 12958-1:2020. The major changes in this revision are as follows:

— introduction of the concept of index versus performance test;

— permission given to test using rigid/rigid, soft/soft or soft/rigid boundaries;

— addition of guidance for testing cuspated sheets on a single side and for testing multilinear drainage geocomposites;

— withdrawal of apparatus types b) and c);

— several cosmetic improvements, in particular terms and definitions, procedure, calculation and reporting.

Since, ISO 12958 has been published in two parts, this standard has also been published in two parts. Other part is as under:

Part 2 Performance test

Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words ‘International Standard’ appear referring to this standard, they should be read as ‘Indian Standard’.
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In the standard intended to be adopted, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 9862 Geosynthetics — Sampling and preparation of test specimens	IS 14706 : 1999 Geotextiles - Sampling and preparation of test specimens	Technically equivalent
ISO 9863-1 Geosynthetics — Determination of thickness at specified pressures	IS 13162 (Part 3) : 2021 Geosynthetics - Determination of thickness at specified pressures (Part 3) : Single layers (*first revision*)	Identical with ISO 9863-1 : 2016

Part 1: Single layers		
ISO 10320 Geosynthetics — Identification on site	IS 17421 : 2020 Geosynthetics — Identification on site	Identical with ISO 10320 : 2019

The technical committee has reviewed the provisions of the following International Standards referred in this standard intended to be adopted and has decided that these are acceptable for use in conjunction with this standard:

International Standard	*Title*
ISO 2854	Statistical interpretation of data — Techniques of estimation and tests relating to means and variances
ISO 5813	Water quality — Determination of dissolved oxygen — Iodometric method

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'.

Extract of ISO 12958-1:2020 Geotextiles and geotextile-related products Determination of water flow capacity in their plane — Part 1: Index test

Foreword

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This first edition of ISO 12958-1, together with ISO 12958-2, cancels and replaces ISO 12958:2010, which has been technically revised.
The main changes to ISO 12958:2010 are as follows:

— introduction of the concept of index versus performance test;

— permission given to test using rigid/rigid, soft/soft or soft/rigid boundaries;

— addition of guidance for testing cuspated sheets on a single side and for testing multilinear drainage geo-composites;

— withdrawal of apparatus types b) and c);

— several cosmetic improvements, in particular terms and definitions, procedure, calculation and reporting.

A list of all parts in the ISO 12958 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

1 Scope

This document specifies a method for determining the constant-head water flow capacity within the plane of a geotextile or geotextile-related product. This document describes the in-plane water flow index test, only applicable to factory-assembled products. For the in-plane water flow performance test, see ISO 12958-2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ISO 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

- ISO 5813, *Water quality — Determination of dissolved oxygen — Iodometric method*

- ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*

- ISO 9863-1, *Geosynthetics — Determination of thickness at specified pressures — Part 1: Single layers*

- ISO 10320, *Geosynthetics — Identification on site*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.
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- — ISO Online browsing platform: available at https://www.iso.org/obp
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3.1 normal compressive stress

σ

Compressive stress normal to the plane of the geotextile or geotextile-related product, expressed in kilopascals [kPa]

3.2 in-plane flow

Q

Fluid flow within the geotextile or geotextile-related product and parallel to its plane, expressed in litres per second [l/s]

3.3 in-plane water flow capacity

$q_{\text{p index}(\sigma/i)}$

Volumetric flow rate of water per unit width of specimen at a defined normal compressive stress (σ), hydraulic gradient (i), measured in the present index test and expressed in litres per second per meter [(l/s)/m]

Note 1 to entry: The term 'transmissivity' is related to laminar flow conditions only and equals the water flow capacity at a hydraulic gradient equal to unity. As non-laminar flow may occur, the term 'water flow capacity' is preferred.

3.4 hydraulic gradient

i

Ratio of the head loss in the geotextile or geotextile-related product specimen to the distance between two measuring points within the geotextile or geotextile-related product

Note 1 to entry: ISO/TR 18228-4[1] provides information on the significance of the hydraulic gradient.

3.5 contact surface

Surface contacting the specimen

Note 1 to entry: Contact surfaces may be either closed-cell foam rubber on both sides (F/F), smooth rigid membrane on one side and closed-cell foam rubber on the other side (R/F) or smooth rigid membrane on both sides (R/R).

3.6 in-plane water flow index test

Test that yields an indication of the in-plane water flow

3.7 in-plane water flow performance test

Test to confirm full compliance of the in-plane water flow with the requirements under specified conditions

भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDRADS

<u>*Draft For Comments Only*</u> Doc: TXD 30 (26521) WC

September 2024

भारतीय मानक मसौदा

भूवस्त्रादि और भूवस्त्रादि से संबंधित उत्पाद – अपने समधरातल में जल प्रवाह क्षमता का निर्धारण

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In this test method, the flow capacity of the product in a given direction is evaluated considering soil confinement, service load and service hydraulic gradient, as well as primary creep. However:

- — For some products and designs, ensuring the product performance may require controlling the flow capacity of the product in both directions, for example for products with discrete draining elements, where the flow capacity significantly depends on the direction of flow. For these situations, the test shall be performed in both directions.

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- ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*

- ISO 9863-1, *Geosynthetics — Determination of thickness at specified pressures — Part 1: Single layers*

- ISO 10318-1, *Geosynthetics — Part 1: Terms and definitions*

3 Terms and definitions

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3.2 in-plane flow

Q

Fluid flow within the geotextile or geotextile-related product and parallel to its plane, expressed in litres per second [l/s]

3.3 performance in-plane water flow capacity

$q_{p\ perf\ (\sigma,i,t,b)}$

Volumetric flow rate of water per unit width of specimen at a defined normal compressive stress (σ), hydraulic gradient (i), seating time (t) and boundary conditions (b), expressed in litres per second per meter [(l/s)/m]

3.4 hydraulic gradient

i

Ratio of the head loss in the geotextile or geotextile-related product specimen to the distance between two measuring points within the geotextile or geotextile-related product
Note 1 to entry: ISO/TR 18228-4[1] provides information on the significance of the hydraulic gradient.

3.5 seating time

Period of time during which the product is maintained under constant compressive stress before a measurement is made, expressed in hours (h)

3.6 boundary conditions

B

Type of materials contacting the specimen on its external faces
Note 1 to entry: Materials may be soil or granular materials, concrete or rigid platen, or any material likely to be in contact with the geotextile or geotextile-related product.

3.7 geotextile intrusion

Effect of the external loads pushing the geotextile into the draining core of the geocomposite, reducing the flow area, on a geocomposite where a geotextile is combined with a draining core

ANNEX 7
(*Item* 6.1)

COMMENTS ON 'IS 17373 : 2020 GEOSYNTHETICS - GEOGRIDS USED IN REINFORCED SOIL RETAINING STRUCTURES - SPECIFICATION'

Commentator: SHRI SOUMENDRA BANERJEE, TERRE ARMEE, NEW DELHI

Comment:

Dear Sir,

On 07 August 2024, we submitted a request to consider few amendments to the code IS 17373-2020, along with the necessary justifications (a copy is attached for reference). Further to that request, we would like to highlight a few pertinent points:

1. IS 17373-2020 is under QCO which have been implemented wef 01 Jan 2024. Presently, all varieties have not been covered in this code and require their urgent incorporation to cover the complete ecosystem of geogrids for reinforced soil structures.
2. Initiatives like the Mega Integrated Textile Region and Apparel (PM MITRA) Parks reflect BIS's vision to elevate Indian manufacturing to international standards. Updating the code is a fundamental requirement to achieve this goal.
3. Organizations such as The Synthetic and Rayon Textile Export Promotion Council (SRTEPC) promote exports. Keeping manufacturing units updated with the latest technology will enhance exports and ultimately fulfill the industry's objectives.

We sincerely request to include the attached comments urgently in the code IS 17373.

Comments of "Terre Armee India" on IS: 17373-2020

In the table below proposed amendments with comments is given for perusal of all members.

Clause No. and Page No.	Proposal (Changes are Underlined)	Justification
Clause No. 4: Types of Geogrids (Page No. 2) b) *Type 2* — Polyester bonded geogrids having tensile strength in machine direction upto 200 kN/m with aperture size in machine direction from 50 to 500 mm and cross machine direction from <u>10 to 100 mm.</u>	b) Type 2 — Polyester bonded geogrids having tensile strength in machine direction upto <u>300</u> kN/m with aperture size in machine direction from 50 to 500 mm and cross machine direction from 10 <u>to 300 mm</u>	• The aperture width will change after 300kN/m. Therefore type 2 and type 3 will be differentiated. • The change in aperture size along the cross-machine direction is recommended, as

		advancements in manufacturing techniques can provide strength even with increased spacing, thereby achieving cost-efficiency. • International codes does not have any mention on aperture openings
c) *Type 3* — Polyester bonded geogrids having tensile strength in machine direction up to 1300 kN/m with aperture size in machine direction from 50 to 1 000 mm and cross machine direction from <u>50 to 200 mm.</u>	*Type 3* — Polyester bonded geogrids having tensile strength in machine direction <u>from 300 kN/m up to 1600 kN/m</u> with aperture size in machine direction from 50 to 1 000 mm and cross machine direction from 50 to <u>500 mm.</u>	• Advancements in manufacturing techniques can provide higher strength. • The change in aperture size along the cross-machine direction is recommended, as advancements in manufacturing techniques can provide strength even with increased spacing, thereby achieving cost-efficiency.
Table 2. Requirements of Uniaxial Polyester Geogrids (Type 2, Bonded)	May delete top row (marked in red box). Add Tensile strength of 130kN and 140 kN and a mention in the notes:	• Tensile strengths of geogrids in top first row is given in MD/CD format. However, this

Table 2 Requirements of Uniaxial Polyester Geogrids (Type 2, Bonded)

(*Clause* 6.2)

Sl No.	Characteristic	Requirement												Method of Test, Ref to
		30/5	40/5	50/5	60/5	70/5	80/5	90/5	100/5	120/5	150/5	175/5	200/5	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	Ultimate tensile strength (kN/m), *Min*													IS 16635
	a) MD	≥30	≥40	≥50	≥60	≥70	≥80	≥90	≥100	≥120	≥150	≥175	≥200	
	b) CD	≥5	≥5	≥5	≥5	≥5	≥5	≥5	≥5	≥5	≥5	≥5	≥5	

intermediate strengths polyester can also be used after satisfying corresponding ultimate tensile strength.

format is not followed in Table 3 and information is infructuous

Table 3. Requirements of Uniaxial Polyester Geogrids (Type 3, Bonded)

(*Clause* 6.2)

Sl No.	Characteristic	Requirement																	Method of Test, Ref to
		50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
i)	Ultimate tensile strength (kN/m), *Min*																		IS 16635
	a) MD	50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	
	b) CD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
ii)	Elongation at designated load in MD and CD, *percent*	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	IS 16635
iii)	UV resistance, strength retained after 500 h exposure, *percent*	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 13162 (Part 2)
iv)	Chemical resistance, strength retained after 72 h immersion, *percent*	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 17363
v)	Width, m	1 to 6 (Tolerance ± 10mm)																	—
vi)	Roll length, m	25 to 200 (Tolerance +1 m with no negative tolerance)																	—

MD: Machine Direction, CD: Cross Direction

NOTE — For weathering and chemical degradation having a range of products identical except for mass per area, it is sufficient to subject only the product with the lowest mass per area to the test. The results of the test may be applied for the other products in the range, unless they have been tested separately.

- It is recommended to use Table 2 for 30 to 300 kN/m and Table 3 for greater than 300 up to 1600 kN/m.

- In Table 2 and 3 geogrids below strength of 200 kN/m is repeated.

- If this table is linked with Type 3 of clause number 4 then a 50 kN/m geogrid will have a aperture size in machine direction from 50 to 1 000 mm and cross machine direction from 50 to 200 mm. This is in contradiction of Type 2

(*Clause* 6.2)

Sl No.	Characteristic	Requirement																	Method of Test, Ref to
		50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
i)	Ultimate tensile strength (kN/m), *Min*																		IS 16635
	a) MD	50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	
	b) CD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
ii)	Elongation at designated load in MD and CD, *percent*	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	≤12	IS 16635
iii)	UV resistance, strength retained after 500 h exposure, *percent*	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 13162 (Part 2)
iv)	Chemical resistance, strength retained after 72 h immersion, *percent*	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 17363
v)	Width, m	1 to 6 (Tolerance ± 10mm)																	—
vi)	Roll length, m	25 to 200 (Tolerance +1 m with no negative tolerance)																	—

MD: Machine Direction, CD: Cross Direction

NOTE — For weathering and chemical degradation having a range of products identical except for mass per area, it is sufficient to subject only the product with the lowest mass per area to the test. The results of the test may be applied for the other products in the range, unless they have been tested separately.

- Ultimate tensile strength (kN/m), in CD to be min 5kN/m

- For higher strength geogrid it important to maintain the geometric structure of the grid and strength in CD

- It is observed that, CD strength is only 1 kN/m for higher tensile strength geogrids, whereas CMD strength is 5

		kN/n for lower strengths.

ANNEX 8
(*Item* 6.2)

COMMENTS ON IS 15909 : 2020 'PVC GEOMEMBRANES FOR LINING - SPECIFICATION (SECOND REVISION)'

Commentator: SHRI ASHISH MOHAN, RMG POLYVINYL INDIA LIMITED

Comment:

Dear Sir,

We would like to introduce ourselves as one of the largest manufacturers of PVC geomembranes in India. We commenced geomembrane production in 2014 in collaboration with Renolit Iberica, a German company, under their brand name *Alkorplan*.

When BIS issued the revised IS:15909 standard in 2020 to cover thicker membranes used for tunnel waterproofing, we were proud to be the first to obtain a license under the updated specifications.

It is worth mentioning that we are also one of the leading manufacturer and exporter of PVC flooring, artificial leather, and sheeting in the country.

With reference to IS:15909, we would like to draw your attention to certain ambiguities in the standard, which allow stakeholders to interpret it according to their convenience. Moreover, the specification lacks long-term aging tests, despite users demanding a service life of 100 years.

Enclosed is a communication from RVNL requesting durability tests for a 100-year life expectancy.

Based on our expertise, we suggest the following amendments to the current standard:

1.**Clause 1.2**: This clause allows project owners to specify additional requirements, which creates ambiguity and leads to confusion. Since we are proposing tests for a 100-year service life, we recommend the removal of this clause, as the enhanced testing will make additional requirements unnecessary.

2. **Signal Layer Thickness**: Although the signal layer thickness is specified, the current standard does not include a method to determine it. We propose the inclusion of a proper testing procedure for signal layer thickness. Furthermore, we recommend that the bottom part of the membrane (apart from the signal layer) consist of at least three layers to minimize the risk of punctures caused by foreign particles. Single-layered membranes are more vulnerable to such incidents.

3. **Peel Strength**: To ensure proper fusion between layers, we propose incorporating a peel strength requirement.

4. **Aging Tests**: Aging tests should be introduced to assess the durability of membranes over time.

5. **Long-term Aging Tests for Tunnels and Mega Structures**: For applications such as tunnels and other large-scale infrastructure projects, where the expected service life exceeds 100 years, we propose long-term aging tests based on the Austrian ÖBV guidelines.

We kindly request that our proposals be discussed as a priority item in the TXD 30 Committee, as this will help eliminate ambiguities. With the rapid development of infrastructure in India, it is essential to ensure that these membranes meet the highest standards for performance and longevity.

Enclosed is a marked copy of the standard with the proposed changes highlighted for your review.

We remain committed to delivering products of the highest quality. For further discussions or clarifications, please feel free to contact us at your convenience.

We look forward to your prompt and positive response.

Thanks & Regards,

Ashish Mohan
+91-9953558658
Executive Director
RMG Polyvinyl India Limited

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENT/STANDARDS

(Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/table/fig. Etc. be stated on a fresh box. Information in Column 2 should include reasons for the comments and suggestions for modified wording of the clauses which the existing text is found not acceptable. Adherence to this format facilitates Secretariat's work)

NAME OF THE COMMENTATOR/ORGANIZATION: RMG POLYVINYL INDIA LIMITED

DOCUMENT NO. OR INDIAN STANDARD: IS 15909 : 2020

Item, Clause Sub-Clause No. Commented upon (Use Separate Box afresh)	Comments	Specific Proposal (Draft clause to be add/amended)	Remarks	Technical References on which (2), (3), (4) are based
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Clause 1.2	This clause should be removed.		It is creating ambiguity and confusion between the stake holders. Since, 100-year life expectancy tests are proposed, this clause	Long term ageing test as per OBV are proposed

			is no longer required.	
Clause 3.2 Category B		Below to be added, **'The bottom part of the membrane should be multi- layered (minimum 3 layers) which are laminated together by heat fusion technology.'**	The multi layered product will minimize the chances of puncture due to the presence of any foreign particle or contamination.	
Table 2 (for Category B)	In the existing standard though the thickness of signal layer is specified but no testing is recommended. Also as proposed above number of layers in the bottom part of membrane should be checked.	Below test to be added to table-2 **Construction of membrane** (a) **Signal layer thickness: 0.2+/-0.02mm** (b) **Number of layers in the bottom part of membrane: 3 (Min)**		
Table 2 (for Category B)	Since, the product is multilayered, the peel strength test should be added.	Below test to be added, **Peel Strength for each set of layers, N/50mm: 100N (Min.)**		
Table 2, Category B	100 year's life expectancy ageing tests should be included in specification	**(Should be added in table as below)**		The Austrian OBV recommends a series of ageing tests of up to one year duration to establish a 100 year`s life expectancy.

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 2010 and was revised in 2015. This standard has been taken up for revision again to incorporate the following major changes:

a) Depending upon the end use and thickness, PVC geomembranes have been classified in two categories.
b) Geomembranes of thickness 2.50 and 3.00 mm and their specific requirements have been incorporated.
c) BIS certification marking clause has been updated.
d) References of Indian Standards have been updated.

The guidelines for installation of PVC geomembranes are given in Annex W for guidance only.

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

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

PVC GEOMEMBRANES FOR LINING — SPECIFICATION
(*Second Revision*)

1 SCOPE

1.1 This standard covers the requirements for PVC geomembrane (flexible polyvinyl chloride) of two categories (Category A and B) depending upon their end use.

1.1.1 Category A includes lining for use in canals, ponds, reservoirs, water features (bodies) for seepage control, for lining of landfills, hazardous waste management, solid waste management and industrial effluent for waste containments and for water proofing of basement, roof/terrace.

1.1.2 Category B includes PVC geomembrane for unexposed application for use in large underground civil structures, basement, road underpasses, waterproofing of rail/road tunnels, bunkers, dams and other mega civil structures. These can also be used for water proofing of unexposed roofs and terrace.

1.2 ~~The tests used to characterize the PVC geomembrane, are intended to ensure good workmanship and quality and are not necessarily adequate for design purposes in view of the importance of environmental factors and specific performance objectives. Tests have been selected primarily with essentially natural aqueous system in mind. Other tests may be necessary to establish chemical resistance and durability under the condition of particular application.~~

2 REFERENCES

The standards listed below 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 editions of the standards indicated below:

IS No.	*Title*
105-B02 : 2014	Textiles — Tests for colour fastness Part B-02 Colour fastness to artificial light : Xenon arc fading lamp test
2076 : 1981	Specification for unsupported flexible polyvinyl chloride sheeting (*first revision*)
3464 : 1986	Methods of test for plastic flooring and wall tiles (*second revision*)
4905 : 2005	Random sampling and randomization procedures (*first revision*)
13162 (Part 3) : 1992	Geotextiles — Methods of test Determination of thickness at specified pressures
16078 : 2013	Geosynthetics — Static puncture test (CBR)
15061 : 2002	Automotive vehicles — Flammability requirements

3 MATERIAL AND MANUFACTURE

3.1 Category A — PVC geomembrane shall be suitably manufactured from vinyl chloride resin homo polymer. Water soluble compounding ingredient shall not be used. Plasticizers that are resistant to migration and bacterial growth shall be used. The PVC geomembrane shall be pigmented to produce an uniform colour. Any dark colour like black, blue, grey and brown etc shall not be used for manufacturing so as to avoid use of recycled material.

3.2 Category B — PVC waterproofing membrane for unexposed applicable shall be made from virgin raw material and shall have a smooth surface. Water soluble compounding ingredient shall not be used. Plasticizers that are resistant to migration and bacterial growth shall be used. The membrane shall be manufactured in twin colour with white signal layer (top layer) of 0.20 mm (with tolerance of ± 0.02 mm) to allow a visual check of the condition of the membrane in case of any damage during the installation. The bottom layer of the membrane shall preferably be in light orange colour. Any dark colour like black, blue, grey and brown etc shall not be used for manufacturing of bottom layer so as to avoid use of recycled material.
The bottom part of the membrane shall be muti-layered (minimum 3 layers) which are laminated together by heat fusion technology. The multi-layered product will minimize the chances of puncture due to the presence of any foreign particle or contamination.

3.3 In case two or more layers of PVC films are used to achieve the final thickness, these shall be joined together by a suitable heat fusion lamination only. The lamination shall be such that the finished material meets the requirements as given in Table 1 and Table 2.

NOTE — Layers shall not be joined by adhesive.

3.4 For making larger panel of geomembranes, two or more sheets of geomembrane shall be joined together by a suitable heat sealing process keeping an overlap of at least 2.5 cm.

4 CATEGORIES AND TYPES

4.1 Based on the end use and thickness of PVC geomembrane, the material shall be classified as under:

4.1.1 Category A

a) *Type I* — Having thickness of 0.30 mm;
b) *Type II* — Having thickness of 0.50 mm;
c) *Type III* — Having thickness of 0.75 mm;
d) *Type IV* — Having thickness of 1.00 mm; and
e) *Type V* — Having thickness of 1.50 mm;

4.1.2 Category B

a) *Type VI* — Having thickness of 2.00 mm;
b) *Type VII* — Having thickness of 2.50 mm; and
c) *Type VIII* — Having thickness of 3.00 mm:

5 REQUIREMENTS

The material shall conform to the requirements as specified in Table 1 for category A (*Type I* to *Type V*) geomembranes and Table 2 for category B geomembranes (*Type VI to Type VIII*).

Table 1 Requirement of PVC Geomembranes, Category A
(*Clauses* 3.3 *and* 5)

Sl No. (1)	Property (2)	Requirement Type I (3)	Type II (4)	Type III (5)	Type IV (6)	Type V (7)	Tolerance (8)	Method of Test, Ref to (9)
i)	Length and width	As agreed					± 1 percent	Annex A
ii)	Thickness, mm	0.30	0.50	0.75	1.00	1.50	± 7.5 percent	3.2 of IS 3464
iii)	Specific gravity	1.30 to 1.40					–	Appendix A (Method A) of IS 2076
iv)	Tensile strength, N/mm^2 (Longitudinal and transverse)	11.28	12.75	13.73	14.72	14.72	*Min*	Appendix B of IS 2076
v)	Elongation at break, percent (Longitudinal and transverse)	250					*Min*	Appendix B of IS 2076
vi)	Tear resistance, N: a) Machine direction b) Cross direction	 20 15	 45 40	 55 45	 75 65	 90 70	*Min*	Annex B
vii)	Index puncture resistance, N	95	230	290	350	425	*Min*	Annex C
viii)	Low temperature crack resistance	Shall not break, crack at (-) 23 ± 2°C	Shall not break, crack at (-) 26 ± 2°C	Shall not break, crack at (-) 28 ± 2°C	Shall not break, crack at (-) 30 ± 2°C	Shall not break, crack at (-) 30 ± 2°C	–	Annex D
ix)	Hydrostatic resistance, kg/cm^2	2.5	4	6	7.5	10	*Min*	Annex E
x)	Seam strength, N	75 percent (*Min*) of original value or unbreakable seam					*Min*	Annex F
xi)	Volatile loss, percent	1					*Max*	**7** of IS 3464
xii)	Peel strength, N/m (*see* Note)	1050					*Min*	**12** of IS 3464
xiii)	Resistance to soil burial: a) Tensile strength, percent change (Longitudinal and transverse) b) Elongation at break, percent change (Longitudinal and transverse)	 5 20					*Max*	Annex G
xiv)	Water extraction, percent loss in weight	0.15					*Max*	Annex H
xv)	Stability to ultraviolet radiations, percent retention in tensile strength and elongation at break	80					*Min*	Annex J

NOTE — Requirement of peel strength is applicable only when the product manufactured is having two or more layers laminated by heat fusion technology to make a homogeneous product of required dimension.

Table 2 Requirement of PVC Geomembranes, Category B
(*Clauses* 3.3 *and* 5)

Sl No. (1)	Property (2)	Requirement Type VI (3)	Type VII (4)	Type VIII (5)	Tolerance (6)	Method of Test, Ref to (7)
i)	Length and width	As agreed ⟷			± 1 percent	Annex A
ii)	Thickness at 20 kPa pressure, mm	2.00	2.50	3.00	+ 10 percent, minus 0 percent	Method A of IS 13162 (Part 3)
iii)	Construction of membrane					
	(a) Signal layer thickness	0.20 ⟷			± 0.02	Annex X
	(b) Number of layers in the bottom part of membrane	03 ⟷			*Min*	Annex V
iv)	Specific gravity	1.30 ⟷			± 0.03	Appendix A (Method A) of IS 2076
v)	Tensile strength, N/mm^2 (Longitudinal and transverse)	17 ⟷			*Min*	Annex L
vi)	Elongation at break, percent (Longitudinal and transverse)	325 ⟷			*Min*	Annex L
vii)	Tear propagation strength, N/mm:				*Min*	Annex M
	a) Machine direction	100	100	100		
	b) Cross direction	100	100	100		
viii)	Behaviour during perforation (Static puncture test), N	2 500	2 800	3 300	*Min*	IS 16078
ix)	Height of fall without perforation, mm	1 100	1 400	1 800	No perforation	Annex N
x)	Cold crack resistance at low temperature, ºC	(-) 35 ºC ⟷			Shall not break/crack	Annex D
xi)	Hydrostatic pressure resistance	Waterproof at 5 bar for 24 h			–	Annex P
xii)	Dimensional stability at 80 ºC for 6 h, percent	3 ⟷			*Max*	Annex Q
xiii)	Change of dimensioning after heating at 70 ºC for 2 h	Stable ⟷			–	Annex R
xiv)	Behaviour after storage in aqueous solution, resistance to acid and alkali after 28 days	Change in tensile and elongation shall be within ± 10 percent of the original value			–	Annex S
xv)	Strength of welded seam shear resistance, N/50 mm	1050			*Min*	Annex T
xvi)	Resistance to puncturing	No perforation shall be observed			–	Annex U
xvii)	Peel Strength for each set of layers, N/50mm	100			Min	Annex V
xviii)	Flammability test, horizontal and vertical rate of burning, mm/min	100		107	*Max*	Annex A and Annex B of IS 15061
	Ageing tests: -					
xix)	Method of accelerated ageing under permanent exposure to	Reduction in tensile strength and elongation at break ≤ 20 %			-	Annex Z

6 DIMENSIONS AND TOLERANCES

The dimensions of PVC geomembrane when tested by the method given in Annex A shall be as agreed to between the buyer and the seller. A combination of width may be seam welded together to obtain desired width of panel. However, no sheet of the PVC geomembrane shall be less than 2 000 mm.

7 COLOUR, SURFACE CHARACTERISTICS AND FREEDOM FROM DEFECTS

7.1 The PVC geomembrane shall be uniform in colour, texture and finish. The PVC geomembrane shall be free from pin-holes and other foreign particles, when tested, by the method prescribed in Annex K. The laminated film shall not peel off.

7.2 The PVC geomembrane shall be reasonably free from defects such as holes, tears or blisters. The edges shall be free of nicks and cuts visible to the naked eye.

8 MARKING

8.1 The PVC geomembrane shall be supplied in roll form and each roll shall bear a label on which the following information shall be provided with indelible ink:

a) Name, category and type of the geomembrane;
b) Name and/or trade-mark of the manufacturer;
c) Thickness and declared length and width; and
d) Batch No. and date of manufacture.

8.2 BIS Certification Marking

The PVC geomembranes conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the BIS Act, 2016 and the Rules and Regulations framed thereunder, and the PVC geomembranes may be marked with the Standard Mark.

9 CONDITIONING OF TEST SPECIMEN

Unless otherwise specified, all samples shall be conditioned at a temperature of 27 ± 2°C and relative humidity of 65 ± 5 percent for a period of 2 h.

NOTE — An alternate conditioning temperature of 23 ± 2°C and relative humidity of 50 ± 5 percent for a period of 2 h or different conditioning time as specified in applicable test methods, may also be acceptable, in case of an agreement between the buyer and seller, without any change in any of the requirements of geomembranes specified in Table 1 and Table 2.

10 SAMPLING

10.1 Lot

In any consignment all the geomembrane rolls of same category and type and dispatched to buyer against one despatch note shall constitute a lot.

a) The number of geomembranes rolls to be selected from a lot shall be in accordance with Table 3. The geomembrane roll shall be selected at random with the use of random number tables (s*ee* IS 4905).

b) The conformity of the lot to the requirements of this standard shall be determined on the basis of the tests on the samples selected from it.

Table 3 Sample Size and Criterion for Conformity
(*Clauses* 10.1 *and* 10.2)

Sl. No. (1)	**No. of Rolls in the Lot** (2)	**No. of Rolls to be Selected** (3)	**Permissible No. of Defective Rolls** (4)
i)	Up to 50	3	0
ii)	51 - 150	5	0
iii)	151 - 300	8	0
iv)	301 and above	13	0

10.2 Criteria for Conformity

The number of rolls selected from the lot shall be tested for various requirements in this standard. If the number of defective rolls or those failing to satisfy any one or more of the requirements is less than or equal to the corresponding permissible number of defective rolls as given in column 4 of Table 3, the lot shall be considered as conforming to the requirement. If the number of defective rolls is more than the corresponding permissible number of defective rolls, the lot shall be considered as not conforming.

ANNEX A

[*Table* 1 *and Table* 2, *Sl No.* (i) *and clause* 6]

MEASUREMENT OF LENGTH AND WIDTH OF PVC GEOMEMBRANE

A-1 MEASUREMENT OF WIDTH OF PVC GEOMEMBRANE

A-1.1 Apparatus

A steel tape capable of measuring to the nearest 1 mm.

A-1.2 Conditioning

Unless otherwise specified, all samples shall be conditioned at a temperature of 27 ± 2°C in air for at least 60 minutes.

A-1.3 Procedure

A-1.3.1 Condition the test specimen as specified in **A-1.2**.

A-1.3.2 Immediately after conditioning, lay the sheet or roll on a flat surface so as to fully expose the width without distortions.

A-1.3.3 Measure the width of the specimen in atleast three different places along its length. During measurement, measuring tape shall be placed as nearly as possible at right angle to the edge of the sheet or roll.

A-1.3.4 Report the average of all three readings.

A-2 MEASUREMENT OF LENGTH OF PVC GEOMEMBRANE

Length of the PVC geomembrance shall be measured by any of the method given in **A2.1** or **A2.2**.

A-2.1 Method A (By using roll length counter)

A-2.1.1 *Apparatus*

Roll length counter, capable of measuring to the nearest 0.01 m.

A-2.1.2 *Conditioning*

Unless otherwise specified, all samples shall be conditioned at a temperature of 27 ± 2°C in air for at least 60 minutes.

A-2.1.3 *Procedure*

A-2.1.3.1 Mount the PVC geomembrane roll on roll length counter and reset the counter meter to zero.

A-2.1.3.2 Now start the rolling length counter and record the reading after the complete unrolling revolutions.

A-2.1.3.3 The reading on the length counter shall be the length of sample in metres.

A-2.2 Method B (By using length measuring wheel)

A-2.2.1 *Apparatus*

Calibrated length measuring wheel, capable of measuring to the nearest 0.01 m.

A-2.2.2 *Conditioning*

Unless otherwise specified, all samples shall be conditioned at a temperature of 27 ± 2°C in air for at least 60 minutes.

A-2.2.3 *Procedure*

A-2.2.3.1 Lay out the test specimen completely flat such that the upper side of the membrane (in situ) is facing upwards.

A-2.2.3.2 Now reset the measuring wheel reading to zero. The reading shall be taken from the centre of the test specimen axis.

A-2.2.3.3 The measuring wheel shall be rolled over to the complete length of the PVC geomembrane roll and the reading in the measuring wheel shall be reported.

A-2.2.3.4 The value so obtained shall be the length of sample in metres.

ANNEX B
[*Table* 1, *Sl No.* (vi)]

TEST METHOD FOR TEAR RESISTANCE

B-1 This test method covers the determination of the tear resistance of PVC geomembranes at very low rates of loading, 51 mm per min, and is designed to measure the force to initiate tearing.

B-2 PRINCIPLE

The force to initiate tearing across a specific geomembrane specimen is measured using a constant rate of grip separation machine. The force necessary to initiate the tear is calculated from the load- time or load-displacement data.

B-3 APPARATUS

B-3.1 Testing Machine – A testing machine of the constant rate of crosshead-movement type and comprising essentially following:

B-3.1.1 *Fixed Member* – A fixed or essentially stationary member carrying one grip.

B-3.1.2 *Movable Member* – A moveable member carrying a second grip.

B-3.1.3 *Grips* – It is preferably a set of self-aligning grips for holding the test specimen between the fixed member and the movable member of the testing machine. The grips should minimize both slippage and uneven stress distribution.

B-3.1.3.1 Fixed grips are rigidly attached to the fixed and movable members of the testing machine. Fixed grips may be used, if extreme care is taken to ensure that the test specimen is inserted and clamped so that the long axis of the test specimen coincide with the direction of pull through the centre line of the grip assembly.

B-3.1.3.2 Self- aligning grips are attached to the fixed and movable member of the testing machine in such a manner that they will move freely into alignment as soon as any load is applied so that the long axis of the test specimen coincide with the direction of the applied pull through the centre line of grip assembly.

B-3.1.4 *Drive Mechanism* – A drive mechanism capable of separating the movable member (grip) from the stationary member (grip) at a controlled velocity of 51 mm ± 5 percent/min.

B-3.1.5 *Load Indicator* – A suitable load-indicating mechanism capable of showing the total tensile load carried by test specimen held by the grips. The testing machine shall be essentially free from inertial lag at the specified rate of testing and shall indicate the load with an accuracy of ± 1 percent.

B-3.1.6 *Crosshead Extension Indicator* – A suitable extension indicating mechanism capable of showing the amount of change in separation of the grips (crosshead movement).

B-3.2 Thickness – The specimen thickness is measured by the test method as specified in method A of IS 13162 (Part 3).

B-3.3 Die – A die having the dimensions shown in Fig. 1 shall be used to cut all specimens. The 90° angle shall be honed sharp with no radius or have minimum practical radius. The cutting edge of the die shall have a 5° negative rake and shall be kept sharp and free from nicks to avoid leaving ragged edges on the specimen. Wetting the surface of the sample and the cutting edges of the die with water may facilitate cutting. The sample shall rest on the smooth, slightly yielding surface that will not damage the die blade. Lightweight cardboard or a piece of leather belting is suitable. Care should be taken that the cut edges of the specimen are perpendicular to its other surfaces and the edges have minimum of concavity.

B-4 TEST SPECIMEN

B-4.1 The test specimen shall be cut out with a die conforming to the dimension shown in Fig. 1 and shall not vary by more than 0.5 percent from these dimension. The cutting edges of the die shall be kept sharp and free from all nicks to avoid leaving ragged edges on the specimens.

B-4.2 Machine direction specimens are cut perpendicular to the machine direction and transverse direction specimens are cut perpendicular to the transverse direction.

B-4.3 Test a minimum of the five specimens each in the machine direction and in the transverse direction.

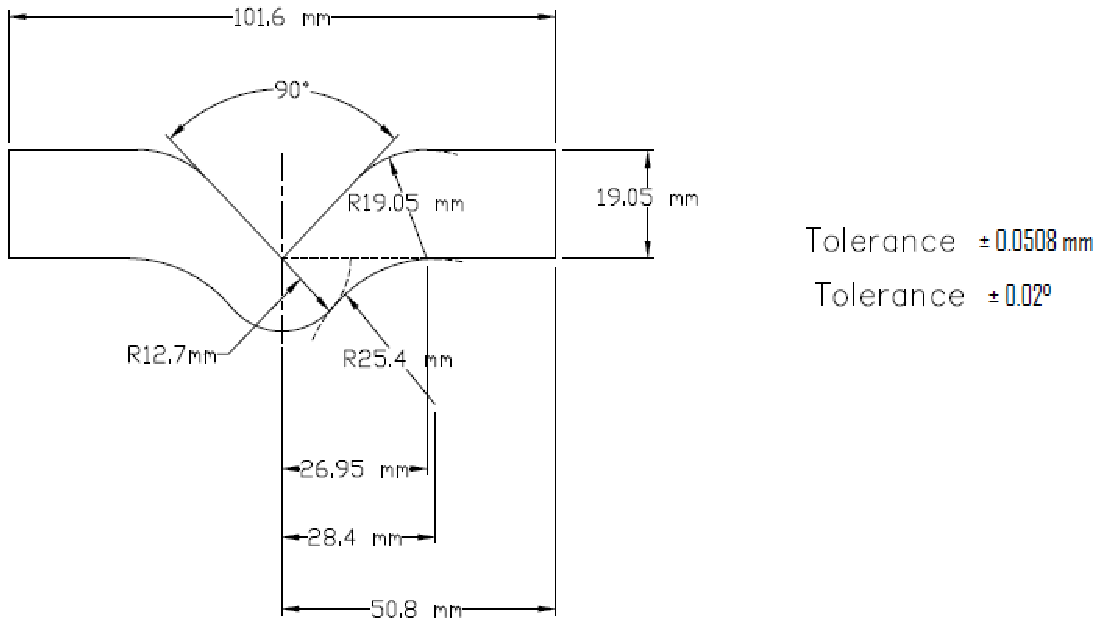


FIG. 1 DIE FOR TEAR TEST SPECIMEN

B-5 CONDITIONING

B-5.1 *Conditioning*

Condition the test specimen at 27 ± 2°C and 65 ± 5 percent relative humidity for not less than 40 h prior to test.

B-5.2 *Test Conditions*

Conduct test in the standard laboratory atmosphere at 27 ± 2°C and 65 ± 5 percent relative humidity.

B-6 PROCEDURE

B-6.1 An initial jaw separation of 25.4 mm shall be used. The rate of travel of the power activated grip shall be 51mm/min.

B-6.2 Measure the thickness of the specimen at several points in the notched area. Record the average thickness, in microns.

B-6.3 Place the specimen in the grips of the testing machine so that the long axis of the enlarged ends of the specimen in the line with the centre line of the grip assembly.

B-6.4 After complete rupture of the specimen, the maximum tearing load, in newtons, shall be recorded.

B-7 CALCULATION

Calculate the mean maximum resistance to tearing for all specimen tested in each principal direction of orientation.

ANNEX C

[*Table* 1, *Sl No.* (vii)]

TEST METHOD FOR INDEX PUNCTURE RESISTANCE

C-1 SCOPE

This test method is used to measure the index puncture resistance of PVC geomembrane.

C-2 PRINCIPLE

A test specimen is clamped without tension between circular plates of a ring clamp attachment secured in a tensile testing machine. A force is exerted against the centre of the unsupported portion of the test specimen by a solid steel rod attached to the load indicator until rupture of the specimen occurs. The maximum force recorded is the value of puncture resistance of the specimen.

C-3 APPARATUS

C-3.1 Tensile/Compression Testing Machine, of the constant-rate-of extension (CRE) type.

C-3.2 Ring Clamp Attachment, consisting of concentric plates with an open internal diameter of 45 ± 0.025 mm capable of clamping the test specimen without slippage. A suggested clamping arrangement is shown in Fig. 2. The external diameter is suggested to be 100 ± 0.025 mm. The diameter of the six holes used for securing the ring clamp assembly is suggested to be 8 mm and equally spaced at a radius of 37 mm. The surfaces of these plates may consist of grooves with O-rings or coarse sandpaper bonded onto opposing surfaces.

C-3.3 Solid Steel Rod, with a diameter of 8 ± 0.01 mm having a flat end with a 45° × 0.8 mm chamfered edge contacting the test specimen's surface (*see* Fig. 2 and Fig. 3).

C-4 TEST SPECIMEN

The test specimens shall be cut from the PVC geomembrane and shall have a minimum diameter of 100 mm to facilitate clamping. If the 100 mm diameter sample is not available, smaller diameter may be taken provided sample is properly clamped. Take fixed numbers of 5 specimens.

C-5 CONDITIONING

Bring the specimens to moisture equilibrium in the atmosphere for testing (65 ± 5 percent relative humidity and 27 ± 2°C temperature). Equilibrium is considered to have been reached when the increase in the mass of the specimen, in successive weightings made at intervals of not less than 2 h, does not exceed 0.1 percent of the mass of the specimen.

C-6 PROCEDURE

C-6.1 Select the load range of the tensile/compression testing machine such that the rupture occurs between 10 and 90 percent of the full-scale load.

C-6.2 Centre and secure the specimen between the holding plates ensuring that the test specimen extends to or beyond the outer edges of the clamping plates.

C-6.3 Test at a machine speed of 300 ± 10 mm/min until the puncture rod completely ruptures the test specimen.

NOTE – The rate of testing specified is not an indication of the performance of the specimen for its end use.

C-7 CALCULATION

Calculate the average puncture resistance and standard deviation for all tests as read directly from the recording instrument.

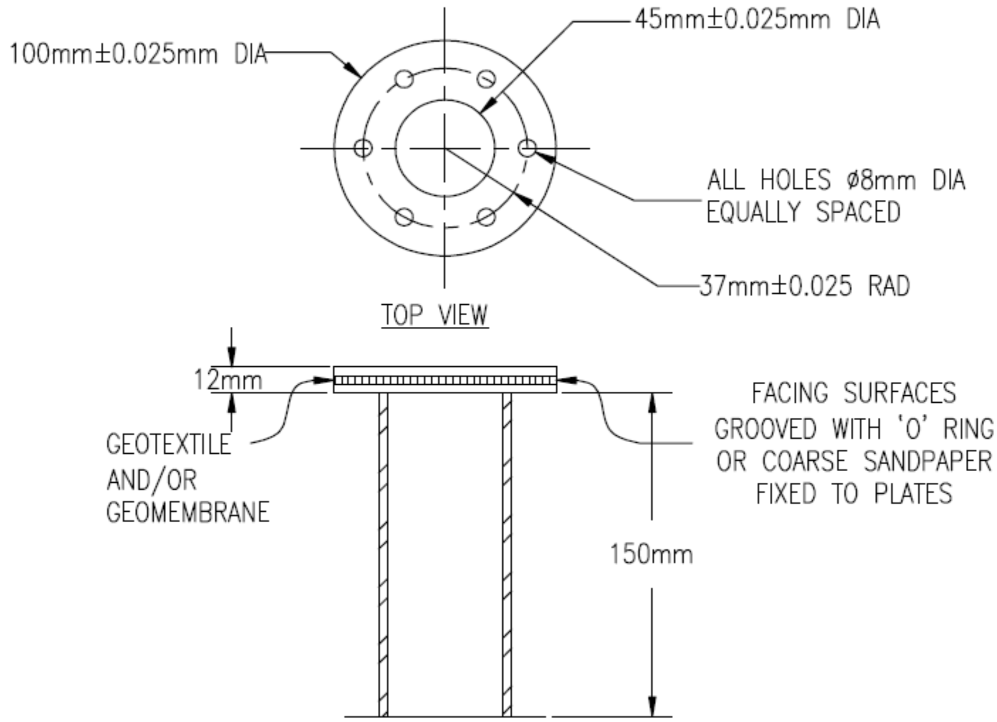


FIG. 2 TEST FIXTURE DETAIL (NOT TO SCALE)

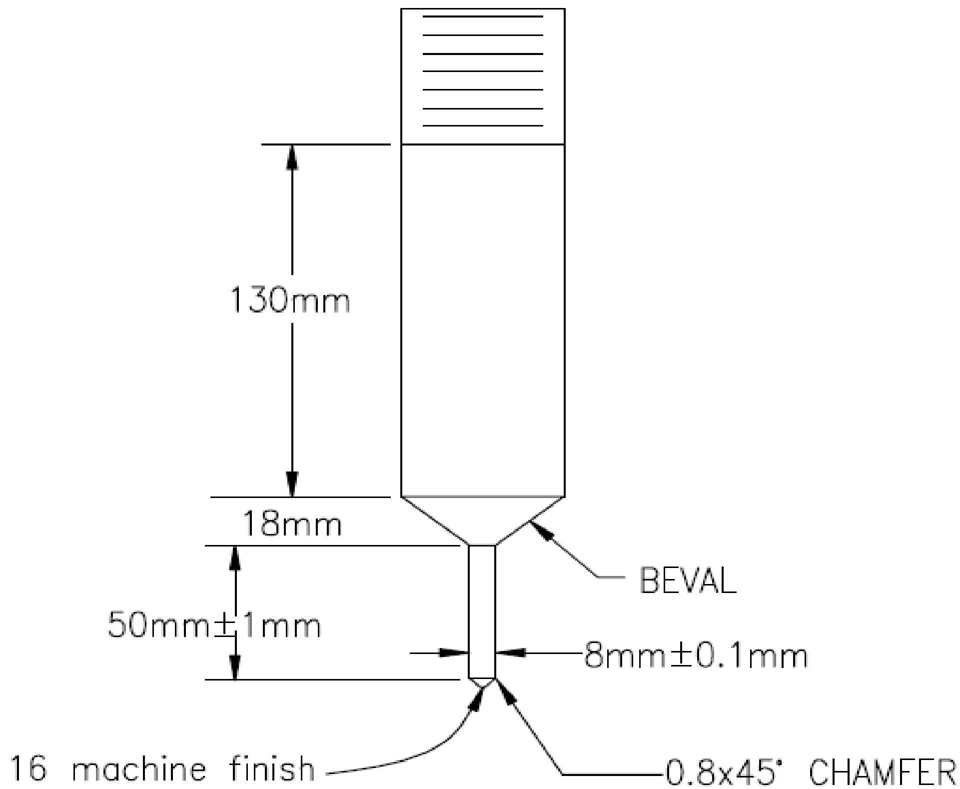


FIG. 3 TEST PROBE DETAIL (NOT TO SCALE)

ANNEX D

[*Table* 1, *Sl No.* (viii) *and Table* 2, *Sl No.* (ix)]

LOW TEMPERATURE CRACK RESISTANCE

D-1 APPARATUS

A 40 mm diameter mandrel and a low temperature chamber suitable to maintain required temperature with a tolerance of ± 2°C.

D-2 PROCEDURE

The test piece shall be a strip of the geomembrane 50 mm wide and 225 mm long. Six test pieces shall be cut at random from the sample. Each test piece shall be kept at the test temperature as given in Table 1 or Table 2 for at least 60 min immediately prior to testing. The mandrel shall also be cooled to the test temperature. The test piece shall be bent by hand over the mandrel with the wearing surface outwards through an arc of 180° in approximately 3s.

D-3 REPORT

The bent portion of the test piece shall be examined in good lighting and under magnification of 4X, and shall be reported for crack, breaks or other signs of failure.

ANNEX E

[*Table* 1, *SI No.* (ix)]

DETERMINATION OF HYDROSTATIC RESISTANCE

E-1 PRINCIPLE

The hydrostatic resistance of the geomembranes shall be determined by Mullen type hydrostatic tester.

E-2 APPARATUS

The testing machine shall permit the clamping of the material to be tested between two circular clamps about 76 mm in diameter having coaxial apertures of their centre 31.5 ± 0.5 mm in diameter. The surfaces of the clamps between which the specimen is to be placed shall be concentrically grooved. The grooves shall be spaced 0.8 mm apart and of a depth not less than 0.15 mm. The grooves shall not start closer than 3.18 mm from the edge of the aperture. The lower clamping surface shall have a recession concentric to the aperture capable of accepting an O-ring having a cross-sectional diameter of 4.7 ± 0.1 mm.

The machine shall have means of applying hydraulic pressure to the underside of the clamped specimen until the specimen fails. The pressure shall be generated by means of a piston forcing water into the pressure chamber of the apparatus at the rate of 1.4 ± 0.1cm^3/s. The machine shall be fitted with a pressure gauge maximum-reading type, with the scale divided to read in kg/cm^2 units. Accuracy shall be 1 kg/cm^2 on readings from 0 to 40 kg/cm^2. When the gauge is calibrated, it shall be mounted in the same relative position as on the bursting tester.

NOTE – Any machine that operates on the above principle and maintains the specified displacement rate of 85 ml/min, and in addition possesses the opening in the upper clamping surface of 31.5 ± 0.25 mm, is a valid machine for this test.

E-3 TEST SPECIMENS

The test specimen cut from the geomembrane shall be of such size that the smallest dimension is at least 12.7 mm greater than the outside diameter of the ring-clamp mechanism of the testing machine.

E-4 PROCEDURE

Before clamping the specimen into the testing machine, bring the water level up flush with the top of the lower clamp so that no air pocket exist between the water surface and the geomembrane being tested. The temperature of the water shall be the same as the atmospheric temperature of the testing room. Increase the pressure steadily in the chamber in which a screw shall operate to force a liquid pressure medium at a uniform rate of 1.4 ± 0.1 cm^3/s. Take a reading at the first appearance of water through the geomembrane being tested. Make ten different determinations and take the average as the hydrostatic resistance of the geomembrane. Discard an isolated high or low result that is not repeated in duplicate when a consistent average has been obtained without the abnormal reading and substitute a re-test.

ANNEX F

[*Table* 1, *SI No.* (x)]

DETERMINATION OF SEAM STRENGTH

F-1 APPARATUS

Tensile testing machine as described in Appendix B of IS 2076.

F-2 PREPARATION OF TEST SAMPLES

A test piece 25 mm wide and approximately 100 mm in length shall be cut at right angles to the direction of the weld in such a manner that seam is equidistant from each end of the test piece. At least three test pieces shall be cut from weld piece.

F-3 PROCEDURE

Place the specimen in the jaws of the tensile testing machine with the seam centered between and parallel to the jaws and width of the specimen at right angles to the direction of application of force. Start the machine and observe by means of an autographic recording device the load necessary to slip the seam or rupture the specimen. The rate of extension of specimen between the jaws shall be 100 mm/min. If a specimen slips between the jaws, breaks or tears in a direction other than parallel to the seam or if for any reason due to faulty technique an individual measurement falls 20 percent below the median test results for the sample unit, discard and test another specimen until six specimens are checked. If the sample breaks other than a seam it should be considered as unbreakable seam or the seam strength is 75 percent (min) of the breaking strength of the same size specimens at the same conditions.

F-4 CALCULATION AND RESULTS

The seam strength of the specimen shall be calculated from breaking load, in kg. The mean value shall be reported.

ANNEX G

[*Table* 1, *SI No.* (xiii)]

DETERMINATION OF RESISTANCE TO SOIL BURIAL

G-1 Prepare a composite soil for the specimen burial according to usual greenhouse practice and having a *p*H of 6.5 to 7.5. Maintaining the moisture content of the soil between 25 percent to 30 percent on an oven dry basis. Perform the test with soil containers stored in a room maintained between 32°C to 38°C. Check the microbiological activity of the soil frequently by burying specimen of untreated cotton duck having mass of 340 to 360 g/m^2 for 1 to 2 week period. Satisfactory activity is indicated by tensile strength losses above 70 percent in 1 week and above 90 percent in 2 weeks of cotton duck.

G-2 Perform the soil burial test by preparing six test specimen three in machine and three in cross machine direction and burying them vertically to the depth of about 200 to 500 mm in soil that is rich in cellulose destroying micro-organism. At the end of 30 days determine the tensile strength and elongation at break in accordance with Appendix B of IS 2076.

ANNEX H

[*Table* 1, *SI No.* (xiv)]

DETERMINATION OF WATER EXTRACTION (PERCENT LOSS IN WEIGHT)

H-1 TEST SPECIMEN

Three test pieces measuring 50 mm × 50 mm shall be cut from the roll.

H-2 PROCEDURE

The test piece shall be immersed completely in distilled water for 24 h at room temperature. Immediately after removal from water, the surfaces of the test piece shall be wiped dry with filter paper and reweighed.

H-3 CALCULATION

$$\text{Water extraction} = \frac{M_1 - M_2}{M_1} \times 100$$

M_1 = mass of the test piece before immersion, in g; and
M_2 = mass of the test piece after immersion, in g.

H-4 REPORT

The average of the three specimen tested shall be reported.

ANNEX J

[*Table* 1, *SI No.* (xv)]

DETEMINATOIN OF RESISTANCE TO THE EXPOSURE OF ULTRAVIOLET LIGHT (XENON-ARC TYPE APPARATUS)

J-1 PRINCIPLE

Specimens of PVC geomembrane for the machine and cross directions are exposed for 500 h of ultraviolet exposure in a Xenon-arc apparatus. The exposure consists of 120 min cycles consisting of 102 min of light only, followed by 18 min of water spray and light. After the exposure, the specimens are subjected to tensile strength and elongation at break as prescribed in IS 2076. The test results are compared to the test results for unexposed specimens and the deterioration which has taken place due to ultraviolet exposure is assessed.

J-2 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

Condition the test specimens to moisture equilibrium from the dry side in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature. When the specimens have been left in such an atmosphere so that both the faces are exposed to the standard atmosphere as far as possible for 24 h, they shall be deemed to have reached the state of moisture equilibrium.

J-3 PREPARATION OF TEST SPECIMENS

J-3.1 Cut 5 test specimens from each of the machines and the cross directions from the test pieces.

J-3.2 Specimens shall not contain dirt, irregular spots, creases, holes or other visible faults.

J-3.3 Any two specimens shall not contain the same longitudinal or transversal position. If it is not possible, it shall be reported.

J-4 APPARATUS

J-4.1 The working details of Xenon-arc apparatus has been described in IS 105-B02.

J-4.1.1 The apparatus should be capable of exposing the specimens to cycles of light only, followed by water spray and light under controlled atmospheric conditions.

J-4.1.2 The apparatus should be equipped with an inner and outer filter glass as described in IS 105-B02.

J-5 PROCEDURE

J-5.1 Operate the Xenon-arc apparatus as given in IS 105-B02 to provide 120 min cycles as follows:

102 min of light only at 65 ± 5°C black panel temperature, and 30 ± 5 percent relative humidity, followed by 18 minutes of light and water spray.

J-5.1.1 Set the minimum level of radiation to 0.5 W/m^2, 1 nm bandpass at 340 nm.

J-5.2 Randomly expose five specimens for each direction for 500 h exposure time. Place 10 specimens (5 for each direction) in the apparatus, such that the side most likely to be exposed to the effects of ultraviolet light will be exposed in the apparatus.

J-5.3 At the end of exposure time, remove the test specimens for tensile strength and elongation at break as given in IS 2076.

J-5.4 Test five unexposed specimens (zero exposure time) and five exposed specimens for each direction for tensile strength and elongation test using cut strip test as given in IS 2076.

J-6 CALCULATIONS

J-6.1 Calculate the average tensile strength and elongation at break for all exposed and unexposed specimens for each direction.

J-6.2 Calculate the percent loss of tensile strength and elongation at break for the exposed specimens for the average results for each direction.

ANNEX K

(*Clause* 7.1)

PIN HOLES AND CRACKS

K-1 Examine for pin holes and cracks by viewing the surface of the PVC geomembrane held under slight tension. Position the bright light source behind the PVC geomembrane so as to clearly illuminate the surface without producing a glare in the observer's eyes. A pinhole is defined as any opening observed in the geomembrane under the condition specified above which is not visible when the geomembrane is viewed normally in average daylight or the equivalent thereof.

ANNEX L

[*Table* 2, *Sl No.* (iv) *and* (v)]

TEST METHOD FOR TENSILE STRENGTH AND ELONGATION

L-1 PRINCIPLE

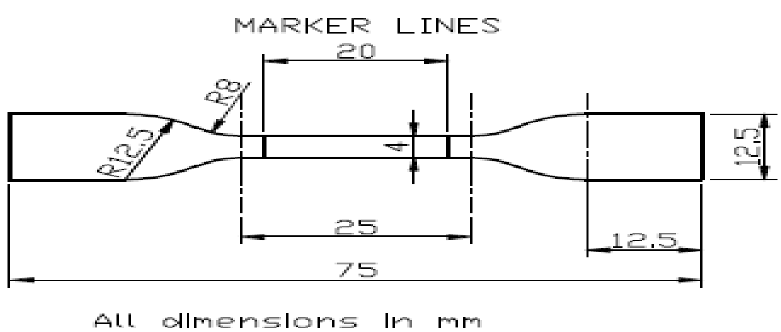
The test specimen is extended along its major longitudinal axis at constant speed until the specimen fractures. During this procedure the load sustained by the specimen and the elongation are measured.

L-2 APPARATUS

Tensile testing machine shall be of at least 2000 N capacity with a constant speed of grip separation (100 ± 10 mm/min). The grip width shall be at least 50 mm. The tensile testing machine shall be equipped with suitable grips that do not allow specimen to slip from the grips.

L-3 PREPARATION OF THE SPECIMEN

The dumbbell shaped test specimens shall be prepared, 5 nos. each in longitudinal and transverse direction as shown in Fig.4.



Over all length (Min.) −75mm

Width of ends − 12.5±1.0mm

Length of narrow parallel portion − 25±1.0 mm

Width of narrow parallel portion− 4.0±0.1 mm

Small radius − 8.0±0.5mm

Large radius − 12.5±1.0 mm

FIG. 4 DUMBBELL SHAPED TEST SPECIMEN

L-4 CONDITIONING

The test specimens, prior to testing, shall be kept for at least 20 h at 27 ± 2 °C and relative humidity of 65 ± 5 percent.

L-5 PROCEDURE

Measure the thickness and width of the specimen. Afterwards the specimen shall be secured in the upper and lower grip of the tensile testing machine ensuring that the marks coincide as accurately as possible with the edges of the grip. The grip separation speed of the tensile machine shall be 100 ± 10 mm/min. A reading shall be taken of the maximum force indicated (at break) and elongation is measured with the help of a divider or any suitable measuring device.

NOTE — The test specimens breaking outside the gauge marks shall be discarded.

L-6 CALCULATION

L-6.1 Tensile strength, (N/mm^2) $T = F/A$

where

T = tensile strength, N/mm^2;
F = force, N; and
A = initial cross-sectional area of the specimen, mm^2.

L-6.2 Elongation percent = $(L_2 - L_1)/L_1 \times 100$

where

L_1 = gauge length of the test specimen, mm; and
L_2 = distance between the gauge marks after extension, mm.

L-7 EXPRESSION OF RESULT

Average values for tensile strength and elongation shall be reported.

ANNEX M

[*Table* 2, *Sl No.* (vi)]

TEST METHOD FOR RESISTANCE TO TEARING (TEAR PROPAGATION STRENGTH)

M-1 PRINCIPLE

The principle of the test is measurement of the force required to completely tear the test specimen in continuation of the cut already produced in the specimen. The tearing force is applied by means of a tensile testing machine at a constant speed until the test specimen tears completely. The maximum peak load shall be reported.

M-2 APPARATUS

M-2.1 Tensile testing machine shall be at least 2000 N capacity with a constant speed of grip separation (100 ± 10 mm/min). The grip width shall be at least 50 mm. The tensile testing machine shall be equipped with suitable grips that do not allow specimen to slip from the grips.

M-2.2 The template used for cutting the test specimens shall have dimensions as shown in Fig. 5.

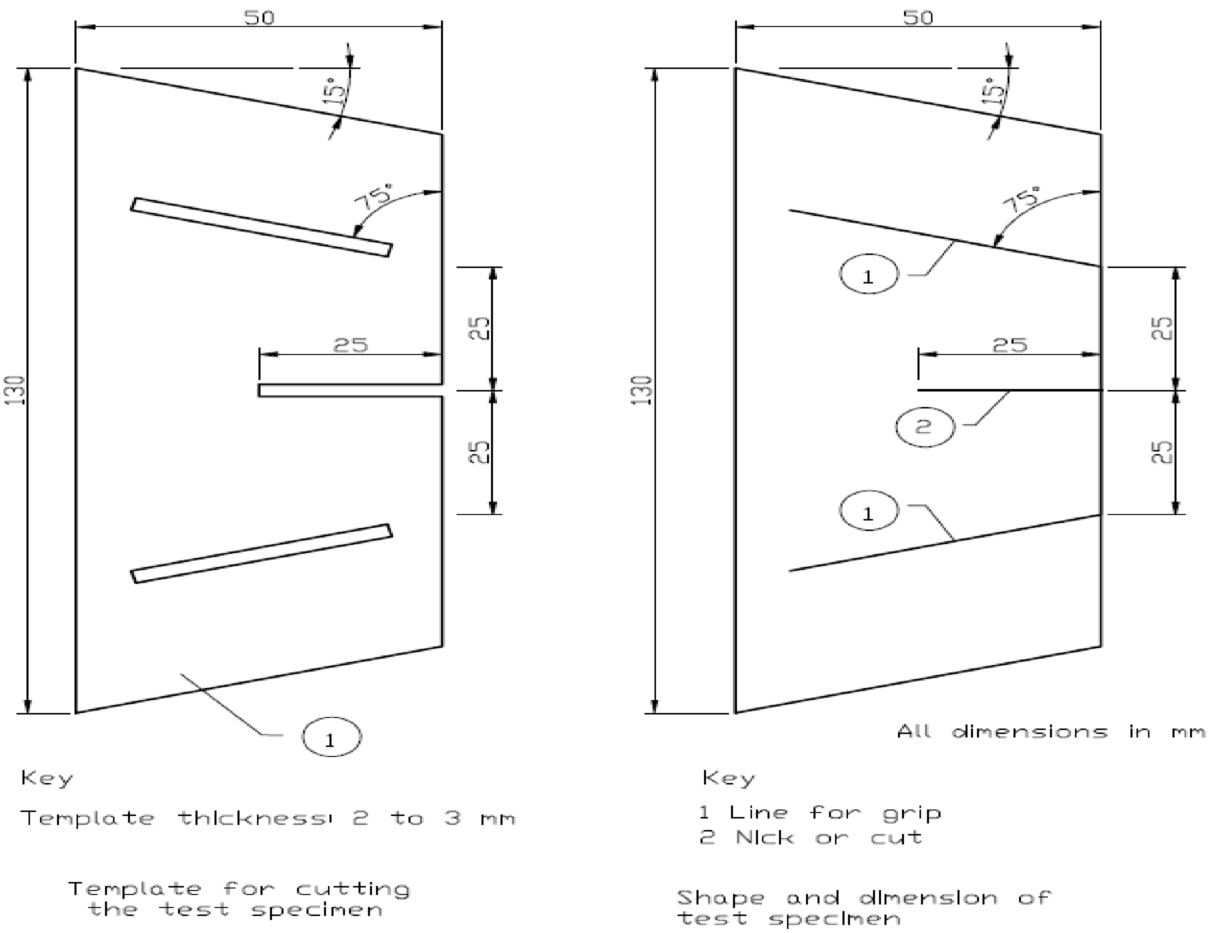


FIG. 5 TEMPLATE FOR CUTTING TEST SPECIMEN FIG. 6 SHAPE AND DIMENSIONS OF TEST SPECIMEN

M-3 PREPARATION OF TEST SPECIMENS

M-3.1 The shape and dimension of the test specimens shall be as given in Fig. 6.

M-3.2 Using the template cut five specimens with nick or cut in the longitudinal direction and five with the nick or cut in the transverse direction of the sheet.

M-3.3 Make lines on every test specimen indicating the position of the grips.

M-4 CONDITIONING

The test specimens, prior to testing, shall be conditioned for at least 20 h in a standard atmosphere of 27 ± 2 °C and 65 ± 5 percent relative humidity.

M-5 PROCEDURE

The thickness of the specimen is measured. Afterwards the specimen shall be secured in the upper and lower grip of the tensile testing machine ensuring that the marks coincide as accurately as possible with the edges of the grip (*see* Fig. 7). The speed of the tearing (grip separation) shall be 100 ± 10 mm/min. A reading shall be taken of the maximum force indicated.

M-6 CALCULATION

Note the maximum force separately for the longitudinal and transverse direction and tear strength is calculated in N/mm as detailed below:

$$TS = L/t$$

where

TS = tear propagation strength;
L = maximum force, N; and
t = average thickness of the specimen, mm.

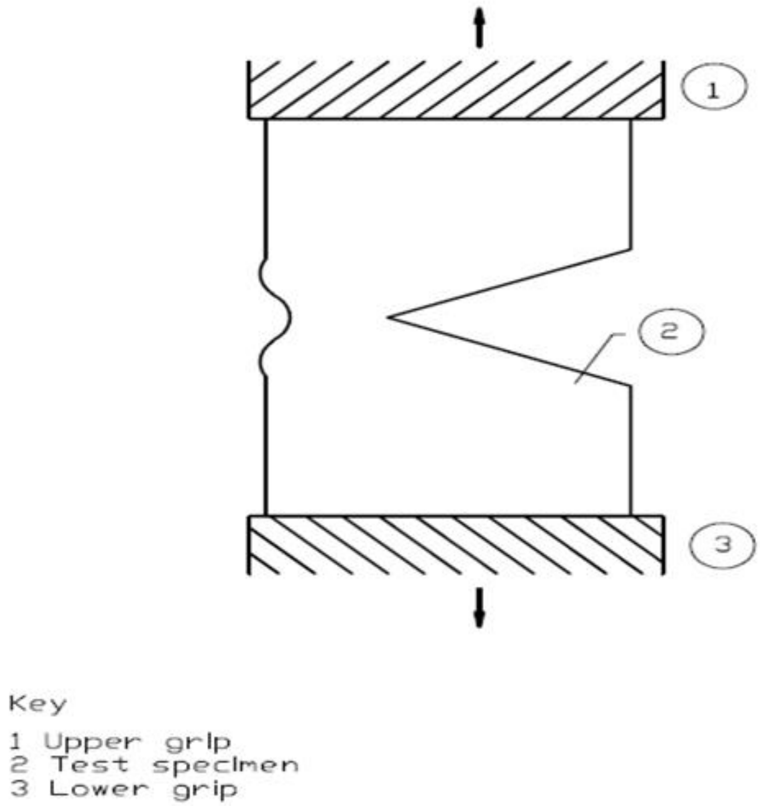


FIG. 7 SPECIMEN IN GRIPS PRIOR TO TEST

M-7 EXPRESSION OF RESULT

Mean value shall be reported.

ANNEX N

[*Table* 2, *Sl No.* (viii)]

HEIGHT OF FALL WITHOUT PERFORATION (IMPACT RESISTANCE)

N-1 PRINCIPLE

To establish whether PVC membrane are punctured at a given test temperature by mass falling from a given height.

N-2 APPARATUS

N-2.1 Steel cylinder of 25 mm diameter and 130 mm length, with a mass of 500 g, into one end face of which a ball of 12.7 mm diameter is pressed, and the other end of which is designed so that the mass can be vertically suspended (electromagnetically or mechanically).

N-2.2 Stand to which the suspension mechanism is attached so as to be adjustable in height.

N-3 PREPARATION OF TEST PIECES

Five specimens of size 150 mm × 150 mm shall be used for testing.

N-4 PROCEDURE

N-4.1 For testing, the test pieces shall be placed on the aluminium plate and pressed down by the metal ring. It shall be noted that the aluminium plate is not to be exposed to impact at the same point more than once.

N-4.2 Assessment whether the sheet has punctured is to be made by applying a positive pressure on the side subjected to impact, using compressed air or, by applying a vacuum on the other side, the pressure differential being 0.1 bar, shall be maintained for one minute.

N-4.3 The test pieces to which the pressure is applied, shall have a diameter of 80 mm. The point of impact shall be coated with a foaming agent. A bursting pressure test apparatus, a slotted disc pressure test device or a vacuum bell jar are suitable equipment for this test.

ANNEX P

[*Table* 2, *Sl No.* (x)]

TEST METHOD FOR HYDROSTATIC PRESSURE RESISTANCE

P-1 PRINCIPLE

This test procedure is used for PVC geomembranes intended for use in high pressure application for example special roofs, tunneling and tanking. In this method, a test specimen is submitted to a specified water pressure for 24 h against a disk containing four slots of specified form and dimension. The test specimen is observed to establish whether it remains watertight.

P-2 APPARATUS

P-2.1 The apparatus consists of a device (*see* Fig. 8 and Fig. 9) by which a pressure shall be applied to one side of a test specimen.

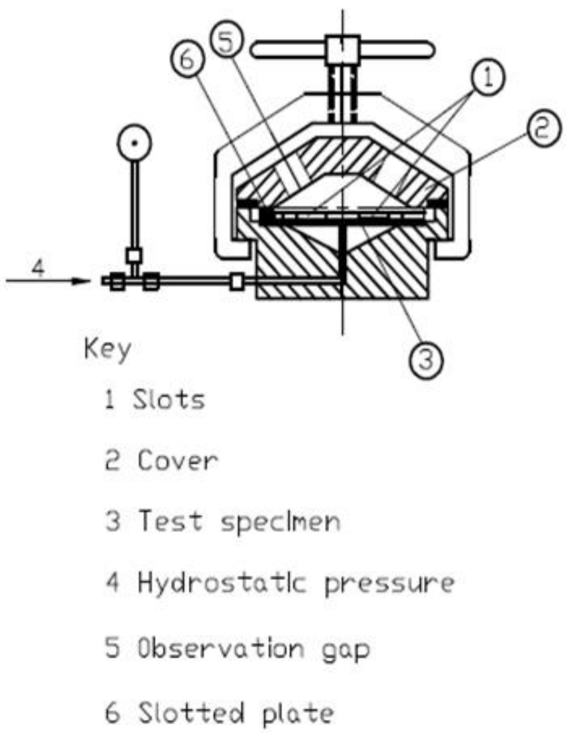
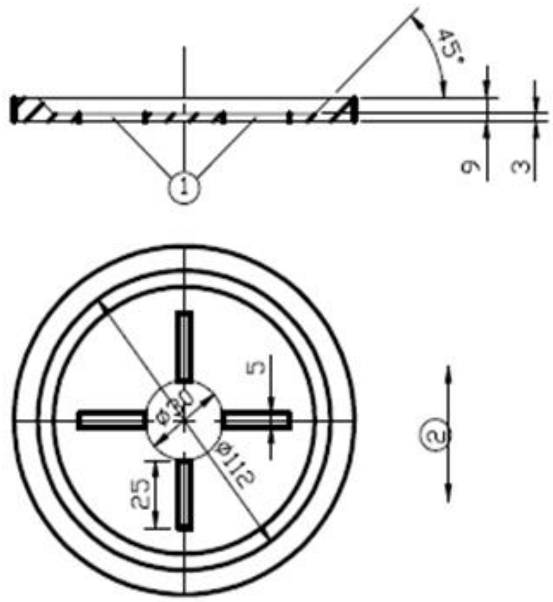


FIG. 8 SLOT PRESSURE TESTING FOR WATER TIGHTNESS AT HIGH PRESSURE

FIG. 9 DEVICE FOR THE SLOT PRESSURE TEST SKETCH OF THE COVER

P-2.2 The test specimen shall be covered by a circular disk containing four slots. The form and dimensions of the slots shall be as specified in Fig. 10.



All dimensions in mm.

KEY

1 All edges of the slotted plate are rounded to a radius of 0.5 mm approximately

2 Longitudinal direction of the membrane

FIG. 10 SLOTTED PLATE

P-3 CONDITIONING OF TEST SPECIMENS

The test specimens shall be conditioned for at least 6 h at 27 ± 2ºC prior to testing.

P-4 PREPARATION OF TEST SPECIMENS

The specimens shall be taken evenly distributed across the width of the sheet, the outer ones 100 mm of the edges. The longitudinal direction on the test specimens shall be marked parallel to direction of production. The number of test specimens shall be a minimum of three. Dimensions of the test specimens shall be circular test specimens with a diameter equal of the external diameter of the slotted plate (approximately 130 mm).

P-5 PROCEDURE

P-5.1 Test Conditions

The test shall be carried out at 27 ± 2ºC and 65 ± 5 percent relative humidity. The test pressure shall be 5 bar. It shall be ensured that the margins are watertight.

P-5.2 METHOD

P-5.2.1 Fill the apparatus (*see* Fig. 8) with water until overflowing. Purge the water line thoroughly.

P-5.2.2 Place the test specimen with its upper side downwards in the apparatus and cover with specified slotted plate, one of the slots (*see* Fig. 10) being parallel to the longitudinal direction of the sheet. Place the cover and progressively tighten until the specimen is tightly in place.

P-5.2.3 Dry the non-exposed side of the specimen with a cloth or with compressed air. Pressurize progressively to the specified test pressure of 5 bar.

P-5.2.4 Once the test pressure of 5 bar has reached, the pressure shall be maintained for a period of 24 ± 1 h.

P-5.2.5 Observe the water tightness of the test specimen after the testing time (sudden pressure drop or presence of water on the non-exposed face of the test specimen.

P-6 EXPRESSION OF RESULTS

The water tightness test shall be considered pass if all the three test specimens remain watertight after the specified testing time.

ANNEX Q
[*Table* 2, *Sl No.* (xi)]

TEST METHOD FOR DETERMINING DIMENSIONAL STABILITY

Q-1 PRINCIPLE

The principle of the test is measurement of the initial longitudinal and transversal dimensions of the test specimen followed by heating of the test specimen for a specified time at a specified temperature.

Resulting longitudinal and transversal dimensions of the test specimens after reconditioning shall be determined and dimensional variations shall be calculated and reported.

Q-2 APPARATUS

Q-2.1 A circulating air oven having thermostatic control that shall maintain a temperature of 80 ± 2ºC and equipped with horizontal rigid metal plates or wired shelves for supporting the test piece. The shelves shall be at least 25 mm larger than the test piece in each direction.

Q-2.2 The measuring device shall be capable of determining the longitudinal and transversal dimensions of the test specimens with an accuracy of at least 0.1 mm.

Q-3 TEST SPECIMENS

Q-3.1 Three test specimens of approximately 250 mm × 250 mm, evenly distributed across the width of the sheet, the outer ones 100 mm ± 10 from the edges shall be taken.

Q-3.2 Test specimens shall be marked as shown in Fig. 11.

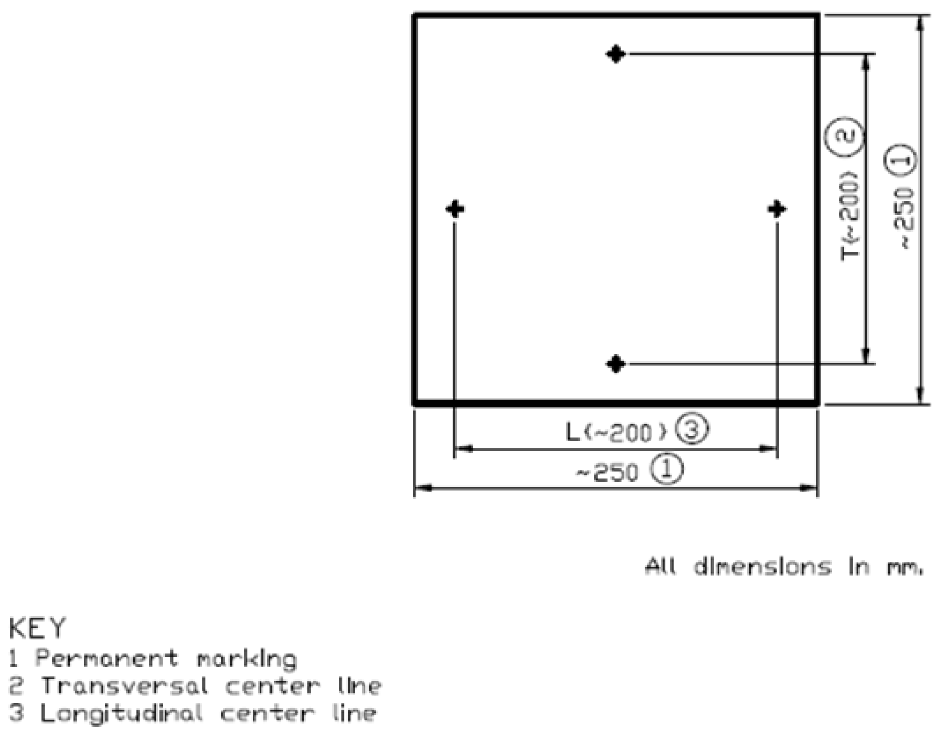


FIG. 11 DIMENSIONS OF TEST SPECIMEN

Q-4 CONDITIONING OF TEST SPECIMENS

Condition the test specimens, prior to testing, for at least 20 h in a standard atmosphere of 27 ± 2ºC and 65 ± 5 percent relative humidity.

Q-5 PROCEDURE

Q-5.1 Measure the initial longitudinal and transversal dimensions (L_0 and T_0) of the conditioned test specimens as indicated in Fig. 11 with an accuracy of 0.1mm.

Q-5.2 Place the test specimens on the plate with the top surface uppermost in the oven at a temperature of 80 ± 2ºC.

Q-5.3 After 6 h, take the test specimens out of the oven on the plate and recondition them for at least 60 minutes in a standard atmosphere of 27 ± 2ºC and 65 ± 5 percent relative humidity. Measure again the longitudinal and transversal dimensions (L_t and T_t) as indicated in Fig. 11 with an accuracy of 0.1 mm.

Q-6 EXPRESSIONS OF RESULTS

Q-6.1 For each test specimen, calculate and state the variation in dimension (ΔL) and (ΔT), expressed as a percentage of initial dimensions, using the equations given below:

$$\Delta L = \frac{L_t - L_0}{L_0} \times 100$$

$$\Delta T = \frac{T_t - T_0}{T_0} \times 100$$

where,

L_0 and T_0 are initial dimensions in mm, measured with an accuracy of 0.1 mm.

L_t and T_t are dimensions after exposure to elevated temperature, in mm, measured with an accuracy of 0.1mm.

ΔL and ΔT can be positive or negative and shall be rounded to 0.1 percent.

Q-6.2 Mean values of ΔL and ΔT for the samples tested shall be reported.

ANNEX R

[*Table* 2, *Sl No.* (xii)]

TEST METHOD FOR CHANGE OF DIMENSION AFTER HEATING AT 70ºC FOR 2 HOURS

R-1 PRINCIPLE

Test specimens taken from the test sample shall be suspended vertically in an oven at a specified temperature. The displacement/change in the dimension of the test specimen shall be measured after a specific time. Failure is defined as a mean displacement/change in dimensions greater than 2.0 mm.

R-2 APPARATUS

R-2.1 Oven with circulating air and a maximum temperature deviation of ± 2ºC in the test area after the door has been opened for 30 s. The recovery period to attain the required temperature again shall not exceed 5 minutes.

R-2.2 Stand for hanging the samples.

R-2.3 Suitable measuring device capable of measuring to an accuracy of 0.1 mm.

R-3 TEST SPECIMEN

Three test specimens of size 100 mm × 100 mm shall be taken.

R-4 CONDITIONING OF TEST SPECIMENS

Condition the test specimen at temperature 27 ± 2ºC and relative humidity 65 ± 5 percent for 2 h prior to testing.

R-5 PROCEDURE

Test specimens shall be suspended vertically at 70 ± 2ºC for 2 h at the same height in the oven with at least 30 mm distance between them. As soon as the heating period is completed, the test specimens together with the stand devices shall be removed from the oven without contact and allowed to cool by hanging freely for at least 2 h at 27 ± 2 ºC, afterwards the hanging stand is removed.

R-6 EXPRESSION OF RESULTS

R-6.1 For each test specimen, calculate the variation in dimension (ΔL) and (ΔT), expressed as change in dimensions, using the equations given below:

$$\Delta L = L_t - L_0$$
$$\Delta T = T_t - T_0$$

where,

L_0 and T_0 are initial dimensions in mm, measured with an accuracy of 0.01 mm in direction A and B.

L_t and T_t are dimensions after exposure to elevated temperature, in mm, measured with an accuracy of 0.01mm in direction A and B.

R-6.2 Calculate the mean values of displacement/change in the dimension (ΔL and ΔT) for the specimens tested.

R-6.3 If the displacement/change in the dimension is not greater than 2 mm, then the test specimen shall be considered as stable.

ANNEX S

[*Table* 2, *Sl No.* (xiii)]

TEST METHOD FOR BEHAVIOR AFTER STORAGE IN AQUEOUS SOLUTION RESISTANCE TO ACID AND ALKALINE

S-1 PRINCIPLE

To determine effect of certain chemicals on PVC Geomembranes.

S-2 APPARATUS

S-2.1 Tensile testing machine of at least 2000 N capacity with a constant speed of grip separation (100 ± 10 mm/min). The grip width shall be at least 50 mm. The tensile testing machine shall be equipped with suitable grips that do not allow specimen to slip from the grip.

S-2.2 Chemicals

S-2.2.1 NaCl, H_2SO_3 and $Ca(OH)_2$

S-2.2.2 Beakers and bottles of minimum 500 ml capacity

S-3 TEST SPECIMENS

The dumbbell size test specimens shall be prepared, 5 numbers each in longitudinal and transverse directions as per Annex L.

S-4 TEST CONDITION

The specimens shall be stored in each one of the aqueous solution separately given in Table 4 at 27 ± 2ºC for 28 days. After removing the samples from the chemicals, these samples are conditioned for 7 days in standard atmospheric condition.

Table 4 Aqueous Solution
(*Clause* S-4)

Sl No. (1)	**Test liquid** (2)
i)	10 percent sodium chloride (NaCl) solution (salt water)
ii)	Milk of lime, $Ca(OH)_2$
iii)	5 to 6 percent sulfurous acid, H_2SO_3

S-5 PROCEDURE

The specimen as per Annex L shall be kept in the chemicals as given in Table 4 for 28 days. After removing the sample from chemicals, these samples shall be conditioned for 7 days in standard atmospheric conditions. Conditioned test specimen shall be tested as per Annex L.

S-6 EXPRESSION OF TEST RESULTS

Average value of test results of variation in tensile strength and elongation shall be reported.

ANNEX T

[*Table* 2, *Sl No.* (xiv)]

TEST METHOD FOR DETERMINING THE STRENGTH OF WELDED SEAM SHEAR RESISTANCE

T-1 PRINCIPLE

The test is to pull a specimen of a joint in shear at a constant speed until it breaks or separates. The tensile force is continuously recorded throughout the test.

T-2 APPARATUS

Tensile testing machine shall be at least 2000 N capacity with a constant speed of grip separation (100 ± 10 mm/min). The grip width shall be at least 50 mm. The tensile testing machine shall be equipped with suitable grips that do not allow specimen to slip from the grip.

T-3 PREPARATION OF TEST PIECES

T-3.1 Test pieces of the sheet are joined by the hot air gun, both for side lap and end lap jointing, with an overlap of 50 ± 1 mm. After jointing, the test piece shall be conditioned for a minimum of 2 h at 27 ± 2°C and at 65 ± 5 percent relative humidity.

T-3.2 From each of these joint test pieces five rectangular test specimens (50 ± 1 mm wide) shall be taken perpendicular to the joint. These shall have such a length, so that the ends of the initial distance between the two grips are 200 mm ± 5 with the joint in the middle (*see* Fig. 12).

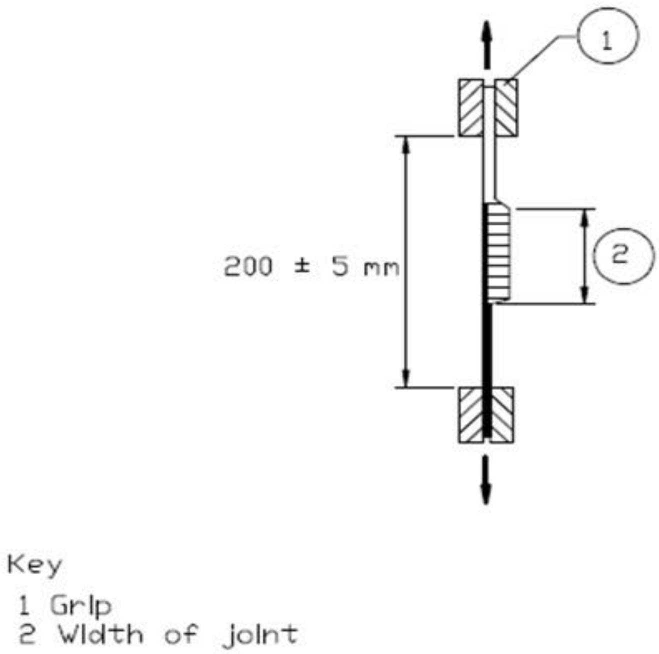


FIG. 12 SHEAR STRENGTH TESTING OF A JOINT

T-4 CONDITIONING

Test pieces to be used for jointing shall be previously conditioned for at least 20 h at 27 ± 2°C and at a relative humidity 65 ± 5 percent.

T-5 PROCEDURE

T-5.1 The test specimen shall be firmly held in the grips of the tensile testing machine, taking care that the longitudinal axis of the test specimen, the axis of the tensile testing machine and the grips are correctly aligned.

T-5.2 Each test specimen shall be marked at the grips in order to identify any slippage out of the grips. The clear distance between the grips shall be 200 ± 5 mm. No preload shall be applied. Test shall be carried out on a test specimen at a temperature of 27 ± 2°C and at a constant separating speed for the grips of 100 ± 10 mm/min. The applied tensile force shall be recorded continuously until the test specimen ruptures or shears. The mode of failure shall be recorded.

T-6 EVALUATION

T-6.1 The mode of failure of the specimen shall be reported. The shear resistance of the specimen is the maximum force recorded during the test.

T-6.2 Individual values for each set of five specimens in newton shall be noted. The shear resistance of the joint as the mean value to the nearest newton shall be calculated and reported.

T-6.3 Any test result where the test specimen breaks less than 10 mm from the grips or slips by more than the permitted limit within the grips of the tensile testing machine shall be discarded and retested with a replacement specimen.

T-7 EXPRESSION OF RESULTS

From the results of each set of 5 test specimen, shear resistance as the mean (using the maximum average shear resistance as occurs for each specimen) expressed in N/50 mm shall be calculated and reported.

ANNEX U

[*Table* 2, *Sl No.* (xv)]

TEST METHOD FOR DETERMINING THE RESISTANCE TO STATIC PUNCTURING

U-1 PRINCIPLE

A concentrated load over a period of time is applied, through a puncturing tool on the surface of the PVC geomembrane while lying on a specified hard support and resistance to static load puncturing is observed.

U-2 APPARATUS

U-2.1 Guide Rail —The guide rail holds the loading rod in vertical position. The vertical movement of the puncturing tool from the surface of the test specimen shall be limited to (40 ± 2) mm by the guide rail.

U-2.2 Loading Rod —The loading rod consists of a puncturing tool at the lower end and a support for the loading discs in the middle. Both shall be calibrated with the support disc to have a mass of 2 kg.

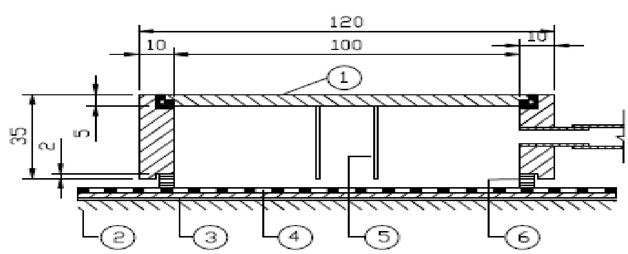
U-2.3 Loading Discs —There is a complete set of four loading discs in which one disc is of 3 kg and other three discs with a mass of 5 kg each.

U-2.4 Puncturing Tool —The puncturing tool is in the shape of a ball having 10 mm diameter. The diameter of thread for attachment to the loading rod is 5 mm. The specification of the puncturing tool material shall be given below:

a) Material : Steel;
b) Hardness : 50 HRC;
c) Ball diameter : 10 ± 0.05 mm; and
d) Polished, unmarked, spherical and defect free.

U-2.5 Support — The test piece is placed loosely directly on a concrete paving slab of about 300 mm × 300 mm × 40 mm. The concrete surface shall be even and free from defects.

U-2.6 Vacuum or Pressure Device — It is used for the verification of possible perforation. The inner diameter of the device shall be at least 20 mm. The schematic diagram of the vacuum device is shown in Fig. 13.



Key

1 Glass plate
2 Supports
3 Air permeable iayer
4 Specimen
5 Transparent plastic tube
6 Gasket

FIG. 13 VACUUM DEVICE (EXAMPLE)

U-2.7 The schematic diagram of the test assembly is given in Fig. 14.

Key

1 vertical movement

2 guide rail

3 loading rod

4 puncturing tool with diameter 10mm

5 clip

6 frames (20mm×20mm)

7 nail

8 test specimen (300×300±2mm)

9 concrete (300mm×300mm×40mm)

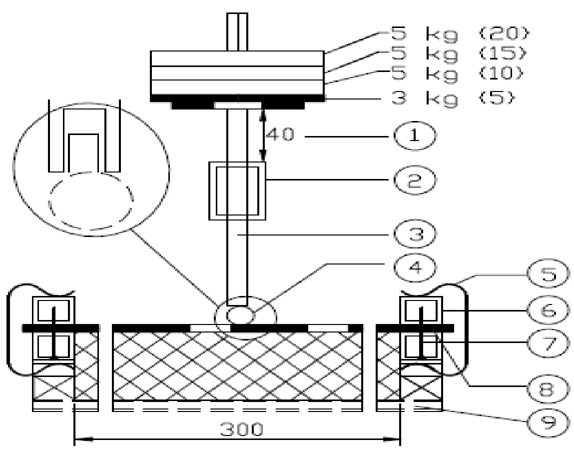


FIG. 14 STATIC LOADING ASSEMBLY

U-3 TEST SPECIMEN

U-3.1 The test specimens shall be cut from the PVC geomembrane with dimensions 300 mm × 300 mm (length × width) with a tolerance of ± 2 mm both sides.

U-3.2 Specimens shall be taken across the width of the roll excluding 100 mm from the edges of the PVC membrane sheet/roll.

U-3.3 Number of Test Specimens

The number of test specimens shall be 3 for each loading stage.

U-4 CONDITIONING

Condition the test specimen at temperature 27 ± 2ºC and relative humidity 65 ± 5 percent for at least 24 h prior to testing.

U-5 PROCEDURE

U-5.1 Maintain the temperature such that the testing shall be carried out at 27 ± 2ºC.

U-5.2 Lay the specimen loosely on the support (*see* **U-2.5)** during testing such that the upper side of the membrane (in situ) is facing upwards (is exposed).

U-5.3 During testing at each loading interval a new test specimen shall be used.

U-5.4 Position the puncturing tool at the centre of the test specimen.

U-5.5 Testing shall be carried out with three test specimens in intervals of loading with initial load of 5 kg. Duration of the loading shall be 24 h for each loading interval.

U-5.6 Increase the load by steps of 5 kg until the perforation is observed or up to a maximum load of 20 kg.

NOTE — Load shall be applied carefully without a shock.

U-5.7 Examine the test specimens for a possible puncture after each loading interval as per method specified in **U-5.8**.

U-5.8 Coat the surface of the membrane where load was applied, with a soap solution within 7 ± 2 minutes after the test. Apply a pressure difference of 15 kPa to the area where the load was applied by means of vacuum or pressure device, with the lower pressure at the surface of the sheet. Examine the test specimen for at least 60 s. If no air bubbles are visible then the test specimen shall be considered as not punctured.

U-5.9 Repeat the procedure for all test specimens and the material under testing shall be considered as resistant to static puncture if all test specimens are found not punctured.

ANNEX W
(*Foreword*)

INSTALLATION GUIDELINES FOR PVC GEOMEMBRANE

W-1 INSTALLATION PROCEDURE FOR LAKE/ RESERVOIRS/ WATER BODIES

W-1.1 Preamble

W-1.1.1 The primary function of geomembrane applied in ponds/ reservoirs is to prevent loss of water due to seepage. The successful performance of geomembrane is based on a good quality material, installation and appropriate design of ponds/ reservoirs.

W-1.1.2 To improve the service lifetime of geomembrane, it is essential that the geomembrane are placed on the pond/ reservoir surface according to the dimensions and contours of the pond/reservoir ensuring full contact with the sub-grade. To achieve this onsite laying, joining and fixing is imperative.

W-1.2 Storage at Site

The geomembrane shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage. The rolls shall be stored on a prepared surface and to be stacked not more than three rolls.

W-1.3 Earthwork and Site Preparation

The selected site shall be free from hard rocks/ murrum, a natural water source, mountain etc. The proposed site shall be free of any decomposable organic materials/vegetation as it can result in upliftment due to generation of gases beneath the geomembrane.

W-1.4 Design and Sub-Grade Preparation

W-1.4.1 The excavation of the pond/ reservoir shall be done in such a way the slope to bed ratio (V:H) shall be 1:1.5 minimum.

W-1.4.2 Sub-grade surface shall be levelled and made free of undesirable angular and sharp fragments, foreign and organic matter, stones and pebbles, as the presence may lead to cause pinholes and or puncture the geomembrane.

W-1.4.3 Soil sterilization may be necessary to kill roots of certain types of grasses by using an effective sterilant/chemical, however the sterilant or the chemical used shall not be detrimental to the liner and shall be applied in accordance with the geomembrane manufacturer's recommendations.

W-1.4.4 The bed and slopes of the constructed pond/reservoir shall be inspected for burrows of crab's rodents, etc. All such burrows shall be emptied by removing the crabs and rodents and disposed off to a safe site away from the pond/reservoir site.

W-1.4.5 The empty burrows and potholes (cavity between the stones) on the bed/slope of pond/reservoir shall be filled with soil. Thereafter it shall be compacted and the entire area shall be cleaned and leveled. The entire area shall be uniform and smooth.

W-1.4.6 A layer of soft soil shall be applied and the top layer of soft bed and slope shall be compacted by water showering for at least 90 percent of proctor density by vibro compaction equipment or by any other suitable equipment or manually.

W-1.4.7 The compaction shall be achieved at least up to a depth of 300 mm from the final sub-grade level of inside of the pond. Perfect compaction and leveling of bed and slopes will give good support to the geomembrane.

W-1.5 Anchor Trench

W-1.5.1 For the purpose of anchoring the geomembrane, an anchor trench of 500 mm × 500 mm × 500 mm shall be excavated at the inside edge of the top of the embankment (*see* Fig. 15).

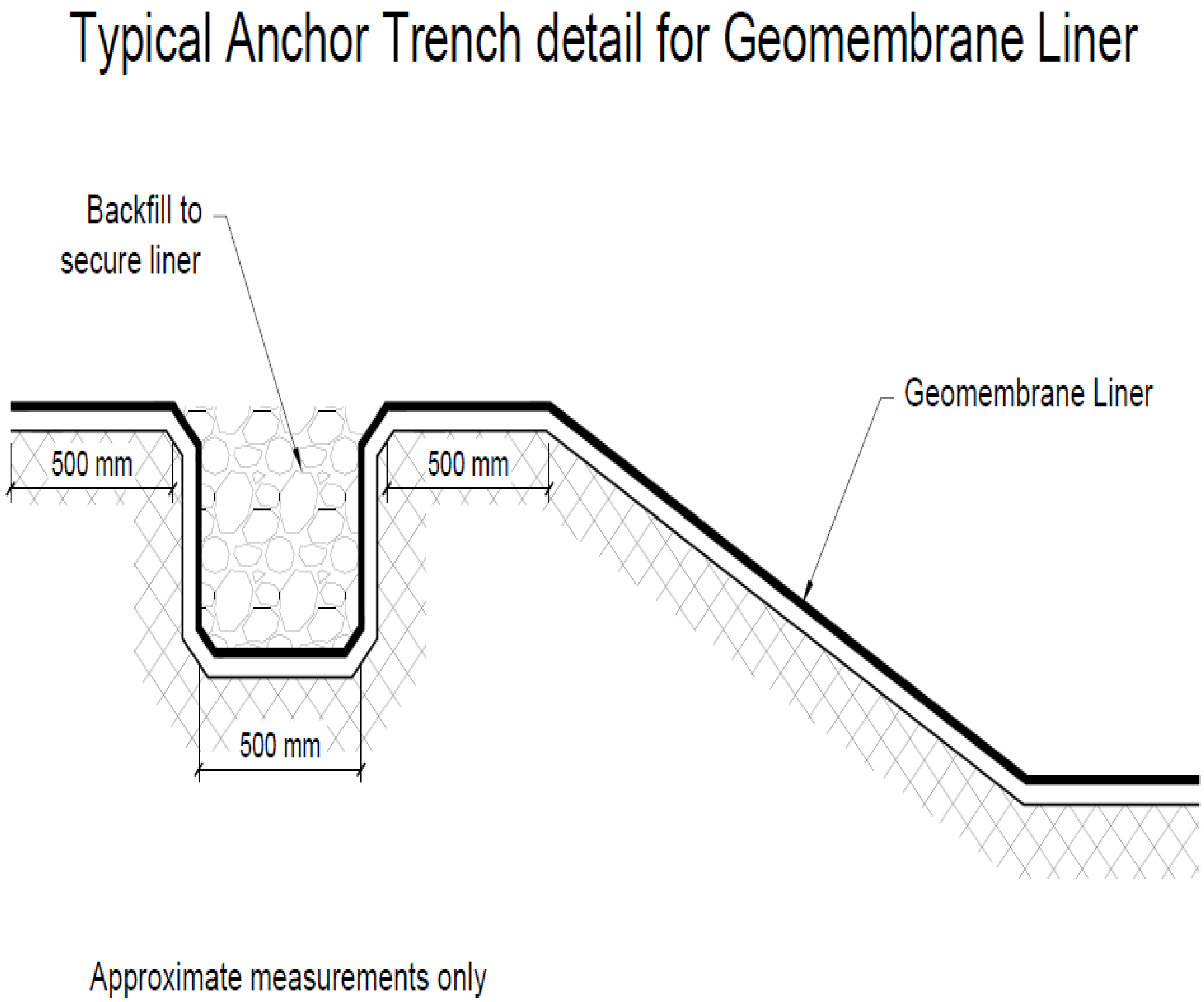


FIG. 15 TYPICAL INSTALLATION OF PVC GEOMEMBRANE

W-1.5.2 Rounded corners shall be provided in the trench to avoid sharp bends in the geomembrane. It is imperative that the anchor trench is complete in all respects before lining work is undertaken to ensure the speed of lining and schedule. The anchor trench shall be back filled after filling the pond, till then filled sand bags shall be kept as counter weight.

W-1.6 Geomembrane Laying Operations

W-1.6.1 Geomembrane panels shall be placed properly on the bed and the slopes with an overlap of 50 to 75 mm for field seeming, or as specified, but not less than 50 mm.

W-1.6.2 Counter weight of filled sand bags along the edges of geomembrane panels and toe of the bunds shall be provided in order to minimize the risk of flow of wind under the panels. The geomembrane interface where seams are to be made shall be clean and free from dust.

W-1.6.3 Geomembrane shall not be laid during rains, any precipitation, in the presence of excessive moisture, in an area of standing water, or during high winds, fog, dew, etc. Geomembrane deployment shall stop in excessive temperatures since this results in imperfect seaming.

W-1.7 Field Seaming of Geomembrane

The fundamental mechanism of seaming geomembrane sheets together is to temporarily reorganize the polymer structure (by melting or softening) of two opposing surfaces to be joined in a controlled manner so that, after the application of pressure, results in the two sheets being bonded together and the joined sheets shall perform as on single geomembrane sheet. Therefore field seaming is a very important and crucial operation and any negligence on this part shall compromise severely the performance of geomembrane system.

W-1.8 Factors Affecting the Field Seams

W-1.8.1 Many factors contribute to the quality of field seam such as ambient temperature, moisture, wind, dust and quality of the field personnel. Field seaming shall be performed when weather conditions are favorable. Seaming below 5°C and above 40°C may result in a decrease in the overall quality of installation.

W-1.8.2 Moisture caused due to precipitation or high humidity is likely to result in improper bonding resulting in failure of seams. Therefore the surface of panel in seaming shall remain dry at all times. Winds causing displacement of geomembrane panels may interfere with the proper alignment of seams, resulting in wrinkles or ‘fish mouths’.

W-1.8.3 The geomembrane panels shall be maintained in a broom clean condition with no dust allowed on or near the seaming areas.

W-1.9 Quality of Field Personnel

The critical parameters for the hot air fusion welding machine are temperature and speed which shall be strictly maintained. Therefore, well trained professionals/technicians shall be employed for field seaming. Excessive melting weakens the geomembrane and inadequate melting results in poor strength. Hence a well-trained technician shall be able to apply adequate melting and pressure making proper seams.

W-1.10 Field Testing of Seams

W-1.10.1 To ensure the quality of seams, it is necessary to have a check on the seams at site by visual and manual methods to identify any defective field seams involving presence of unbounded or open seams, fish mouth created due to wrinkles and restraints, burning of liner due to excessive heat during thermal bonding.

W-1.10.2 For seams between adjacent sheets of waterproofing membranes, the testing for tightness shall be carried out by means of compressed air pumped in to the test channel which is formed by the double welded joint. Initial test pressure shall be 2 bars for a test period of 5 minutes or 1.5 bar for a test period of 10 minutes. The joint shall be considered waterproof if the loss of air pressure in both cases is not more than 20 percent.

W-1.11 Post Installation Precautions

W-1.11.1 If there is no proposal of fixing cover system over the geomembrane, the pond/reservoir shall be filled as soon as possible after installation work to ensure that the geomembrane fully adheres to the sub-grade surface.

W-1.11.2 A shade net shall be laid at corner of the pond/reservoir. There are chances of some reptiles entering into the pond, in spite of fencing. These reptiles can't come out of the pond/reservoir as they cannot crawl on the geomembrane. Hence to prevent damage to the geomembrane, shade nets shall be installed at the corners over the geomembrane.

W-2 INSTALLATION OF THE PVC GEOMEMBRANE FOR TUNNEL LINING

W-2.1 Description

W-2.1.1 The purpose of the membrane waterproofing to underground structures is to prevent leakage of groundwater into the tunnels and to protect the final concrete lining against deleterious chemical influences. Waterproofing shall be applied to crown and sidewalls above footing or invert arch level. The waterproofing membrane shall always be located between shotcrete support and final concrete lining. As the underground structures referred to be not immersed below a distinct groundwater table no membrane waterproofing shall be provided for tunnel inverts.

W-2.1.2 The waterproofing system shall consist of two layers: the first shall consist of a protective felt fastened to the shotcrete surface; the second layer shall be the actual waterproofing membrane properly fixed by special means as recommended by the manufacturer.

W-2.1.3 While the sealing function shall be provided by the membrane, the layer of felt is required to protect the waterproofing membrane against damage from contact with the shotcrete surface, to prevent interlocking between concrete and shotcrete in case of differential movements of shotcrete support and final lining and to provide a drainage layer allowing to drain off groundwater into the longitudinal lateral drainage pipes, thus preventing a build-up of hydrostatic pressure on the tunnel lining.

W-2.2 Surface Preparation

All surfaces to which waterproofing is to be applied shall be sufficiently clean smooth and free from deleterious materials and projections. The following treatment of surfaces shall be performed prior to the installation of waterproofing:

a) For the fixing of the protective felt and the waterproofing membrane minimum shotcrete cover of 50 mm to rock is required.

b) Irregularities of the shotcrete lining surface shall be eliminated by means of additional shotcrete. The ratio of the diameter to depth of irregularities shall be not less than 5:1. Rounding at rock bolts (where applicable), etc shall have a minimum radius of 0.3 m.

c) Transitions and intersections of tunnel profiles shall be rounded off with a minimum radius of 500 mm.

d) Protruding steel bars, wires, spacers, pipes etc shall be cut of unless treated with additional shotcrete cover.

e) Exposed steel parts such as rock bolts, if not intended to remain accessible shall be covered with shotcrete.

f) All shotcrete surface shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0.8 mm), applied in a layer of 50 mm minimum thickness.

W-2.3 Fixing of Felt

The protective felt (geotextile) of minimum 4 mm thickness for protection of waterproofing membrane and drainage on the finished outer lining surface shall be attached to the shotcrete surface using suitable fixings specified by the manufacturer. Depending on the location, 2 to 4 number of roundals shall be used per square meter. The felt shall be laid with sufficient slack to avoid overstress during concreting. Adjacent sections of felt shall be overlapped by 100 mm and joined by point welding or similar suitable method. Along the bottom of the tunnel side walls, the felt shall extend sufficiently to cover the lateral drainages.

W-2.4 Fixing of Waterproofing Membrane

Adjacent sheets of waterproofing shall be joined by a double weld. Along the bottom of the tunnel side walls the membrane shall extend sufficiently to cover the lateral drainages.

W-2.5 Fixing of Protective Membrane

With above joining procedure, the protective membrane is fixed to the water proofing one by means of thermal welding or by glueing of velcro and felt disks systems on the two membranes and connecting.

W-2.6 Testing of Seams

All seams shall be tested and records of these tests shall be submitted by the contractor to the engineer.

W-2.7 Seam Test with Compressed Air

For seams between adjacent sheets of waterproofing membrane, the testing for tightness shall be carried out by means of compressed air pumped into the test channel which is formed by the double welded joint. Initial test pressure shall be 2 bars for a test period of 5 minutes or 1.5 bar for a test period of 10 minutes. The joint shall be considered waterproof if the loss of air pressure in both cases is not more than 20 percent.

W-3 CONSTRUCTION QUALITY ASSURANCE (CQA) OF PVC GEOMEMBRANES

W-3.1 Construction Quality Assurance (CQA) — A planned system of activities that provide assurance that the facility was constructed as specified in the design. Construction quality assurance includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for the project.

W-3.1.1 The quality of the waterproofing system should be controlled for its entire service life. During first filling, drain discharge must be continuously monitored, and records subjected to interpretation as the reservoir level rises. Control of drain discharge must continue during the operational life of the structure, so that any deviation from the normal drain discharge will signal the possibility of abnormal functioning of the system. Visual inspection, and leak detection systems, can spot the damage if any.

W-3.2 Procedures to Assure Survival

W-3.2.1 For any geomembrane sealing system to function properly, it is necessary that the geomembrane survive the packaging, transportation, handling, and installation demands that are placed on it. This aspect of design cannot be taken lightly or assumed simply to take care of itself. Some of the major variables affecting a given situation are the following:

a) Storage at the manufacturing facility;
b) Handling at the manufacturing facility;
c) Transportation from the factory to the construction site;
d) Offloading at the site;
e) Storage conditions at the site;
f) Temperature extremes at the site;
g) Subgrade conditions at the site;
h) Deployment at the approximate location;
j) Movement into the final seaming location;
k) Treatment at the site during seaming;
m) Exposure at the site after seaming; and
n) Placement of the cover material or soil backfill on the completed geomembrane where applicable.

W-3.2.2 With a well-planned construction quality assurance (CQA) document, competent full-time inspection by CQA personnel, and cooperation of the installation contractor, the geomembrane can survive to the point of beginning to function as designed.

W-3.2.3 While being stored, transported, handled, and installed, geomembranes are most often vulnerable to tear, puncture, and impact. Such events often come about accidentally, by vandalism, or by poor workmanship. Typical situations are the dropping of tools on the geomembrane, the driving of autos or pickup trucks on the unprotected liner, high winds getting beneath the geomembrane during placement, the awkwardness of moving large sheets of the geomembrane into position, and so on.

W-3.3 CQC Items

W-3.3.1 CQC includes:

a) Acceptance of materials at site;
b) Acceptance of surface;
c) Installation of geotextile supporting the geomembrane;
d) Installation of geomembrane sheets/panels;
e) Installation of fastening system on upstream face if applicable;
f) Field joints of geomembrane sheets/panel;
g) Water tightness of perimeter seals;
h) Final concluding inspection of geomembrane;
j) Placement cover layer if applicable; and
k) Final concluding inspection of geomembrane sealing system (after cover placement).

W-3.3.2 The waterproofing contractor should provide the CQA manual related to the waterproofing works prior to starting of construction of the sealing system, to allow all parties involved to familiarize and become conscious of the possible mutual influences of the various construction steps. The CQA manual must address procedures for installation and inspections, tolerances, testing procedures and standards, corrective actions, and must include QC forms for all documented steps of QC. Depending on how construction is organized, some of the above steps can be performed and documented together.

W-3.4 Acceptance of Materials at Site

All materials shall arrive at site with relevant documentation identifying their characteristics. QC shall verify by their labels that they correspond to specifications and that they are in conditions adequate for installation.

ANNEX -V

DETERMINATION OF PEEL STRENGTH FOR EACH SET OF LAYERS
&
DETERMINATION OF NUMBER OF LAYERS

V1 Principle: To determine the peel strength for each set of layers (top to middle, middle to middle and middle to bottom) of PVC Geomembrane.

V2 Apparatus & Test Reagent: A tensile testing machine having the rate of movement of 280 ± 25 mm per minute of the driven grip measured. The machine shall be capable of reading to ± 2 N (0.2 kgf), Beaker -250 ml & Reagent- Ethyl acetate of pure grade (lab grade).

V3 Test Specimen: Six test pieces each measuring 150 X 50 mm shall be cut direction of longitudinal 03 pieces & transverse 03 pieces from the specimen.

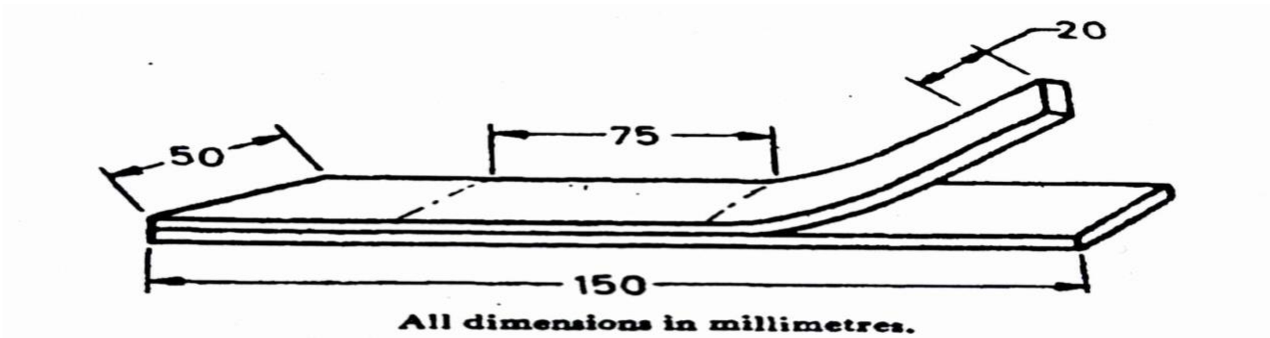
V4 Procedure:

V4.1- Separation of layers / Preparation of test specimen for peel strength test:

V4.2-Procedure for peel strength:

The width of each test piece shall be measured at the three -quarter points and the average shall be regarded as the width of the test piece. Three parallel lines shall be marked on the surface of each test piece (see Fig 1). Each test piece shall be supported vertically for the period of 45 minutes in ethyl acetate to a depth of not more than 20 mm. After immersion that part of the laminate which has been in the solvent shall be separated by hand but without undue force. (Wet PVC tend to break easily.)

The test pieces shall then be allowed to dry at a temperature of 27 ± 2^0 C until all the solvent has evaporated and in any case for not less than 90 minutes. Each test piece shall then be separated in the tensile testing machine. The load for separation of 75 mm marked section of the test piece shall be noted.



All dimension in millimeters
Fig 1

V 5.0 Expression of Result:

Peeling strength for each set of layers in test piece for direction machine and transverse **shall** be recorded and result **shall** be mentioned as below,

a) Load of separation of any layers **shall** be min.100N – Passes the test
b) If layer breaks before separation of 30 mm, then it will be considered as fused- Passes the test

*NOTE:-If layers do not get separated in 40 minutes, the immersion period may be extended upto 2 hrs and specimen **shall** be checked for separation of layers after every 30minutres. If no separation is observed, specimen must be kept immersed for 24 hrs to check whether it is a multilayered product or not.*

If there is no apparent separation of three layer in any of the specimen after immersion for 24 hrs in ethyl acetate, The material will not be considered as multi-layered.

Annex -X

DETERMINATION OF THICKNESS OF SIGNAL LAYER

X1 Principle: The thickness of signal layer shall determine by a measuring device. If there is hindrance by removal of signal layer to its backing. In this case, optical measurement shall be used.

Method – (A) Measuring device

X2-A Apparatus: Dial Thickness Gauge, with an accuracy of 0.01 mm. The measuring surfaces shall be planar and have a dimeter of (10 ± 0.05) mm exerting a pressure of (20 ± 10) kPa on the sheet surface.

X3-A Test Specimen: Six test pieces each measurement 150 X 50 mm shall be cut in the direction of longitudinal 03 pieces & transverse 03 pieces from the specimen.

X4-A Procedure: Separate the signal layer as per the procedure given in annexure -V. The test pieces shall then be allowed to dry at a temperature of 27 ± 2^0 C until all the solvent has evaporated and in any case for not less than 90 minutes. Check the zero point of the measuring device before starting the measurements and recheck after each series of measurements. When determining the thickness, lower the foot gently to avoid deforming the material.

X5-A Expression of Result:

Check the thickness of each specimen and record the mean value.

Method –(B) Optical device

X2-B Apparatus: Microscope (magnification of 10X or 20X), Razor -sharp knife

X3-B Procedure: For Measure optically the thickness of signal layer. The small specimen for optical measurements **shall** not be longer than 10 mm. The small specimen shall be cut with a razor-sharp knife from each test specimen. The cut cross section of the specimen shall be installed in angle of $(90 \pm 5)^0$ to the direction of viewing, using a microscope and print the viewing image of the microscope. Measure the ratio of thickness to the total thickness as per given fig 1.

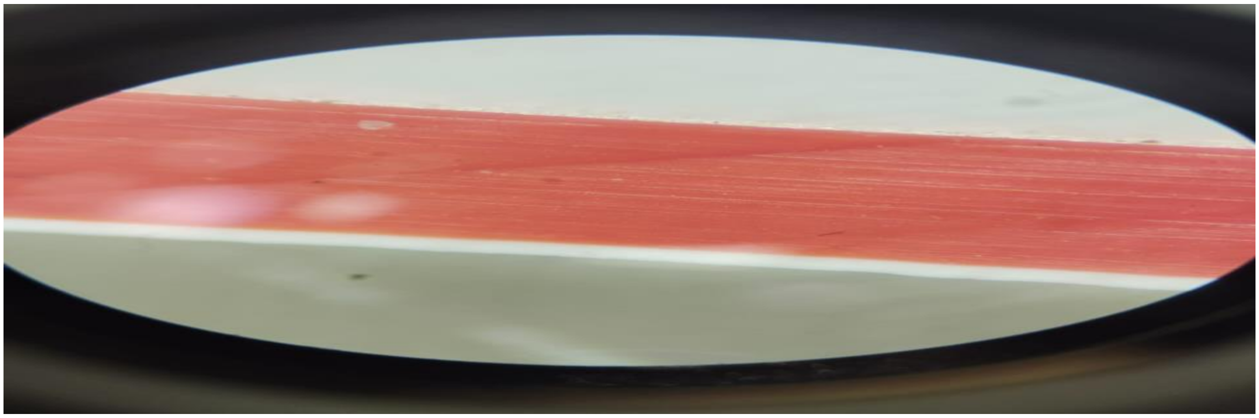


Fig 1.

X4-B EXPRESSION OF RESULT:
Ratio of signal layer to the original thickness should be under 9 % to 11 % in microscopic image for each measurement.

ANNEX -Y

TEST METHOD FOR BEHAVIOUR AFTER IMMERSION

Y1 Principle: This test is used to determine the behaviour of PVC Geomembrane after immersion in aqueous solutions & hot water.

Y2 Apparatus:

- **Analytical balance:**
  -Weighing range min. 200 g
  -Accuracy min. 0.01 g
- **Water bath with the following requirements:**
  -Container made of inert, non-corrosive materials
  -Away from light, e.g. by covering
  -Water quantity per specimen 1 litre minimum
  -Constant internal water bath circulation at a flow rate of 25 to 100 % of the capacity per hours
  -Water temperature control at ± 2^{o}C
- **Drying Chamber:**

-Convection temperature to dry the specimen at 50 ± 2^{o}C desiccant (silica gel or calcium chloride)

Y3 Test Specimen: Four specimens, 02 longitudinal and 02 transverse, Size (20 X 30 cm).

Y4 Procedures:

Y4.1 Determination of dry mass:

The specimens are stored for 24 hours in a drying chamber at 50 ± 2^{o}C and then cooled to room temperature in an exsiccator with desiccants.
Immediately after removal from the exsiccator, the specimens are weighted individually to the nearest 0.01g (Mass M1).

Y 4.2 Immersion (Aqueous solution / Hot water) :

The aqueous solution / Hot water **shall** be maintained at a specified temperature of 50^{o} C with an accuracy of ±2^{o}C throughout. Immediately after weighting of dry mass, the specimens are immersed fully in the temperature -controlled aqueous solution / Hot water so that they are free-floating (use a weight if necessary). Material placed in water bath must all have the same. Contact between the specimens and container walls or any weights used must be prevented.

The aqueous solution / Hot water must be replaced weekly by the same volume within 30 minutes.

Any deposits in the bath must be removed.

Y4.3 Duration: The test duration must be 12 Months (360 days). Determine the mass changes of the specimens after 1,2,4,8 and 12 months

Y4.4 Measurement and analysis:

Y4.4.1 Mass Change:

At the end of the immersion period, the specimens are dried with a non – fibrous filter paper. The mass change of the specimens is then determined by drying at 50 ± 2 ^{o}C in a convection drying chamber.

After drying for 24 hours and cooling, the first determination of mass by weighting takes place. This is followed by drying for a second time for 24 hours. Then weighting for second time. If the weight after the second drying varies by less than 0.20 % from the weight after the first drying, the weight after second drying is used as drying mass M2.

If weight reduction is greater, drying continue for 24 hours at 50 ± 2 ^oC each time, until a weight changes of less than 0.20 % is obtained.
The mass changes M2-M1 in % is determined after 1, 2, 4, 8 & 12 months (as applicable) on all specimens.

Y4.4.2 Visible defect: After immersion for 360 days, the specimens **shall** be free from visible defects.
.
Y4.4.3 Tensile Strength & Elongation at break: After immersion in 12 months (360 days), the tensile strength and elongation at break (according to Annex -L) is determined on the dried specimens.

Y4.4.4 Reduction in impact load (drop height): After immersion in 12 months (360 days), the reduction in impact load (drop height) (according to Annex - N) is determined on the dried specimens.

Y4.4.5-Dimensional Change (where applicable): After immersion for **12 months (360days)** the dried specimens shall be checked for dimensional change as per Annexure Q (**only for measurement**).

Y5.0 Expression of result:

Test results: Before and after immersion and the changes.

a) Mass Changes
b) Visible defects
c) Tensile and Elongation at break.
d) Reduction in impact load (drop height)

(Should clearly mention the date of start and end of test).

ANNEX -Z

TEST METHOD FOR ACCELERATED AGEING UNDER PERMANENT EXPOSURE TO ELEVATED TEMPARATURES

Z1 Principle

This test method shall be used to determine the accelerated aging of PVC geomembrane under permanent exposure to elevated temperatures.

Z2 Apparatus

A thermostatically regulated oven with air circulation, capable of exposing test specimens to a specified temperature, with a tolerance of ± 2°C, shall be equipped with hanging rigid metal plates or wired shelves to support the test pieces.

Z3 Test Specimen

Total 4 specimen of size 20cm X 30cm (02 longitudinal and 02 transverse)

Z4 Test Procedure

Z4.1 Oven Temperature

Set the oven temperature as specified ± 2°C

Z4.2 Specimens

Place the specimen in the oven once the temperature has reached a steady value. Place the specimens in the center of the oven, not touching each other.

Z4.3 Duration of the Oven Test

The duration of exposure and temperature shall as specified

Z4.4 Determine Tensile Strength & Elongation at Break

When the fixed time period of oven ageing has elapsed, the specimens shall be removed from the oven and cooled at 27 ± 2 °C for 4 hours. The tensile strength and elongation at break shall be measured for exposed specimens according to Annex L. The average percentage reduction in tensile strength and elongation compared to the original results shall be recorded

Z4.5 Low temperature foldability test (where applicable)

After heat exposure the specimens shall be tested for foldability at low temperature (as specified) as per Annex D.

ANNEX 9

(*Item* 6.3)

COMMENTS ON IS 18591 : 2024 'GEOSYNTHETIC REINFORCED SOIL STRUCTURES - CODE OF PRACTICE'

Commentator: SHRI AANAND JAIN, GREEN INFRASTRUCTURES SYSTEMS PVT. LTD.

Comment:

Dear Sir,

Good evening,

Recently we came to know about IS 18591:2024, related to guidelines "Geosynthetics soil structures-code of practice", clause 33.1.3.4.

In above reference minimum panel thickness has been mentioned 160mm. However, we request you to revise it. The panel thickness 140mm is sufficient (excluding any architectural finishing) using galvanized steel connections using polyester geogrid and in this reference, we are submitting our credentials for your review purposes.

We are an organization working in this field since 2010 (Incubated by SINE IIT Bombay) and completed more than 55 projects across India comprising several NHAI and STATE GOVERNMENT projects.

Recently we have completed NHAI projects with M/s RAJPATH INFRACON-PUNE and M/s BANASAL CONSTRUCTION - BHOPAL using panel thickness 140mm.

Please find approval letters also in support of 140 panel thickness.

We request you to consider our concern seriously to review purposes. If any discussion needed, we are ready for presentation at your office.

International code like FHWA-NHI-10-024 also support 140mm panel thickness for RE walls for Highway projects.

Indian Code IRC SP 102: 2014 also support panel thickness 140mm.

It is very unjustified that already working internationally and nationally panel thickness modified without reviewing the internation codes and national working code.

It seems that all companies related to RE walls have not invited for discussion and one-sided decision has been taken.

ANNEX 10

(*Item* 6.4)

Date: 30-Oct-2024

To,
The Head — Textile Dept.
Bureau of Indian Standards,
New Delhi

Sub: Request letter for clearance of shipment of "Non-woven Geotextile by PP Fibre" vide bill of entry # 5646657 Dated 17/09/2024 and 5645441 Dated 17/09/2024

Dear Sir,

With regards to the shipment as mentioned in subject line we would like to bring the following to your notice:

1. 1.We have imported product "Non-woven Geotextile by PP Fibre" with details as in subject line.

2. 2.The subject shipment was imported as an integral part of raw material required to assemble the final structure of Defencell Mac. Intended end-use **(Annexure I)** is to retain the fill material inside the Defencell units and act (once filled) as defensive barriers against potential threats of blast, fire and hostile vehicle intrusion. Without the GTX, the Defencell Mac units will not be able to retain the fill material and serve their purpose of defensive barrier against potential threats perceived by our Defence forces. As product specifications and end-use and does not fall under any IS, BIS certification on the product is considered as not applicable for the import.

3. However, Customs have seized the subject shipment vide Seizure Memo dated 8-Oct-2024 **(Annexure II)** on the grounds that the product falls under IS 16392 **(Annexure Ill)** whereas the same is meant for geotextiles for permanent erosion control in hard armour systems

4. We, as a responsible organisation understand the order and compliance requirement as required by the standard. However, the scope of standard reads as (screen shot as below):

Indian Standard

GEOSYNTHETICS — GEOTEXTILES FOR PERMANENT EROSION CONTROL IN HARD ARMOR SYSTEMS — SPECIFICATION

1 SCOPE

1.1 This standard covers general and performance requirement for geotextiles used between energy absorbing armor systems and the in-situ soil to prevent soil loss resulting in excessive scour and to prevent hydraulic uplift pressures causing instability of the permanent erosion control system.

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

1.3 Woven slit film geotextiles, that is, geotextiles made from yarns of a flat, tape-like character, shall not be used for permanent erosion control applications.

NOTES

1 This is a material purchasing specification and design review

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

3.2 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 over awning. Sediment control can only attempt to minimize the extent of these problems.

5. As defined in the scope of standard it is applicable when the product is used to prevent soil loss resulting in excessive scour and to prevent hydraulic uplift pressure causing instability of the permanent erosion of control system.

6. We would like to draw your attention to point number 1.2 of scope where it is clearly mentioned that "standard does not apply to other type of geo-synthetic erosion control such as turf reinforcement mats"

7, The imported product end use is not to prevent soil loss as defined in the scope of standard and intended use of product is to prepare protective wall using local filler material which acts as defensive barrier against potential threats of blast, fire and hostile vehicle intrusion. The intended use of product shall fall under point number 1.2 of scope of standard IS 16392.

JUSTIFICATION:

We understand certification from BIS against standard 16392 is effective from January 2024 effective implementation order.

We also understand the scope as defined in standard which mandates for compulsory BIS certification for product if end use is soil protection — **Annexure III: ,Standard IS 16392**

Further end use of our product does not fall under the scope of standard as justified above in point number 5. Declaration cum undertaking in this regard attached — **Annexure I: Declaration and undertaking for end use of product**

We also have 3rd party test reports (Annexure IV) of sub GTX and compared the same with IS 16392 and comparison report is attached — **Annexure IV: Third Party Test Report and Annexure V: Comparison of DEFCEL GTX and IS 16392**

Also the supplier test certificate issued by the supplier does not fall under IS 16392 — **Annexure VI: Supplier Test Report**

Submission and Request to BIS:

As explained above with justification, we request your kind office to please allow to clear the goods as **end use of our product does not fall within the scope of standard IS 16392 or any other IS such as IS 15910 or IS 16391 or IS 16392 or IS 16393.**

Any further evidence, of end use of product, may be provided if required.

Undersigned may be contacted for any further query/clarification.

On behalf of MACCAFERRI ENVIRONMENT SOLUTIONS PRIVATE LIMITED

(Vijender Rao)

Annexures:

Annexure I: Declaration cum Undertaking of End-use Annexure II: Seizure Memo

Annexure III: IS 16392

Annexure IV: Third Party Test Report

Annexure V: Comparison of DEFCEL GTX and IS 16392

DECLARATION CUM UNDERTAKING

This is to declare and undertake that product imported shipment vide bill of entry no. 5646657 Dated 17-09-2024 & bill of entry no. 5645441 Dated 17-09-2024 is intended to be used for manufacturing of Defencell Mac, which acts as defensive barrier against potential threats of blast, fire and hostile vehicle intrusion. Without GTX, the Defencell Mac units will not be able to retain the fill material and serve their purpose of defensive barriers against potential threats perceived by our Defence forces.

Further it is hereby undertaken that the imported goods shall not be used as Geotextiles used between energy absorbing armor systems and the in-situ soil to prevent soil loss resulting in excessive scour and to prevent hydraulic uplift pressures causing instability of the permanent erosion control system.

The declaration is being made to BIS and Customs, if any further evidence about uSe Of product IS required the same be made available post sale of goods.

For any further query/clarification undersigned may be contacted.

On behalf of MACCAFERRI ENVIRONMENTAL SOLUTIONS PRIVATE LIMITED

(Vijender Rao)

Justification for "Non-Woven Geotextile " as an inte•ral • art of raw material required to assemble the final structure of Defencell Mac.

Along with welded mesh panels, non-woven geotextile (GTX) is an integral part of the Defencell MAC. The technical data sheet (TDS) of Defencell Mac is enclosed in Annexure I. The primary function of the GTX is to retain the fill material inside the Defencell units. Once filled, the Defencell Mac units act as defensive barriers against potential threats of blast, fire and hostile vehicle intrusion. Without the GTX, the Defencell Mac units will not be able to retain the fill material and serve their purpose of defensive barrier against potential threats perceived by our Defense forces.

I. Utilities of Non-Woven Geotextile are listed below:

1. Retention

As mentioned in the introduction above, GTX allows for the local fill material (available at site) to be retained inside the Defencell Mac units. Further, the specified GTX allows for the use of local fill material to be used. This enables our Armed forces to create defensive barriers in the most remote locations and eliminates dependency on specific fill material (like good soil, aggregates etc.). The detailed specification of the GTX is enclosed in Annexure II.

2. Drainage

The GTX allows for the retention of fill material inside the Defencell Mac units and permits the drainage of water (due to rain, snow and hail). Due to this inherent drainage capability of the GTX, the fill material does not get drained, and the structural integrity of the defensive barriers created using the Defencell Mac is retained. In the absence of GTX, any other filter or separation medium will allow for complete drainage of the fill material, which will have to be re-filled multiple times. This will hinder the operational preparedness and safety of our forces.

3. Environmental protection

As Defence!! Mac units are used in the most remote locations across country, they are exposed to versatile and challenging climatic conditions. Being installed in field areas, the most common and harshest exposure comes from Ultraviolet (UV) rays. Commonly used geotextile (used behind conventional retention structures), on exposure to UV rays, starts to disintegrate and thereby lose their structural integrity. The specified GTX is manufactured from UV stabilized virgin polypropylene fibers, that have been mechanically bonded and thermally treated. Compliant to ASTM D4355-2018 and EN 12224:2000, the UV stabilized X can withstand the harshest climatic exposures.

4. Burn Propagation

Armed forces install Defencell Mac units for protection against threats like improvised explosion devices (IEDs), storage of hazardous materials like (but not limited to) ammunition, fuel etc., and fortification against multiple variant weapon firing. In all applications, the Defencell Mac unit is exposed to varying degree of fire. The GTX is subjected to rigorous burn propagation test to ensure high degree of safety and protection. The GTX, when exposed to an open flame for 20 seconds, simulating potential fire hazards, does not allow for enhanced propagation of fire and limits the damage to local (exposed to flame) area only. This ensures the fire does not spread to the entre Defencell Mac units, along with adjacent connected units (if installed).

II. Compliance to Global standards

Further to our submission, we hereby inform that the specified GTX confirms to relevant global standards like EN 12447-2001, EN ISO: 13438-2004, EN 12225:2000, EN 12224:2000, STM D4886-2018, ASTM D4355-2018, EN ISO 9863:2016, 1S012956-2010, ISO 9864:2005, ISO 12236-2006, ISO 13433-2006 and ISO 11058-2019. Compliance with these standards is essential for safety and performance of the GTX to be used in Defencell Mac manufacturing.

III. Summary

GTX is an integral part of the raw material for Defencell Mac because they are fundamental to the product's structure, functionality, safety, and compliance with industry. standards. Their absence would compromise the product's effectiveness and its ability to fulfill its intended purposes. Therefore, it's essential that GTX is recognized and cleared as a crucial component for the manufacturing process.

Authorized signatory,

For Maccaferri Environmental Solutions Private Limited (MESPL)

Sahil Choudhary
Business Unit Head – DT & Defence
Email: S.choudhary@maccaferri.com
Mobile: +91-9871128678, +91-9772000001

SEIZURE MEMO DATED 08.10.2024

1	Name & address of party	:	“M/s Maccaferri Environment Solution Private Limited, Pandoga kariyan, Una, Himachal Pradesh – 177207 (IEC: 0398016321)
2	Date & place of detention/seizure	:	08.10.2024 at import Shed, ICD GDL, Sahnewal, Ludiana, Punjab.
3	BE No & Date	:	5645441 dated 17.09.2024 & 5646657 dated 17.09.2024
4	Description and Quantity Commodity & Chapter (declared)	:	Defcel A GTX MAC 19 T BEG NONWOVEN GEOTEXTILE BY PP FIBER” of different sizes under CTH 56039490.
5	Value and duty involved in seized/detained goods	:	Value: Rs. 1,17,03,970/- + Rs. 1,24,34,556/-Rs. 2,41,38,526/- Duty: Rs. 42,88,335/- + Rs. 45,56,021/- = Rs. 88,44,356/-
6	Estimated duty nvolved in offending goods other than seized goods, if	:	…
7	Modus operandi	:	The importer has misclassified the imported goods i.e. 'NONWOVEN GEOTEXTILE' under CTH 56039490(other) of the Tariff Act instead of CTH 56039410 which is specifically for "Nonwoven geotextile and articles thereof conforming to IS 16391, IS 16392' and therefore not complied the BIS
8	Rules/Section contravened	:	Section 17 read with Section 46, 46(4) and 46(4A) of the Customs Act, 1962 and provisions of other allied acts.
9	Name of the officers and role played	:	Sh. Santokh Singh. Assistant Commissioner Sh. Ajay Syal, Superintendent Sh. Rakesh Singh, Superintendent Sh. Yashwant Barak, Inspector

Brief facts of the case:

Briefly stated that M/s Maccaferri Environmental Solution Private Limited through its CB Divya Singh filed a Bill of Entry 5645441 dated 17.09.2024 & 5646657 dated 17.09.2024 under RMS Order for import of Defcel A GTX MAC19 T BEG "NONWOVEN GEOTEXTILE BY PP FIBER" of different sizes under CTH 56039490 (other).

On perusal of the Bill of Entry filed by the importer through its CB, it was found that the importer has classified the imported goods in the Bill of Entry under CTH 56039490 which is "Other" category of main heading 5603-Nonwoven articles instead of CTH 56039410 which is specifically for' Nonwoven geotextile and articles thereof conforming to IS 16391, IS 16392".

Further, vide Quality Control Order S.0 1706(E) called as Geo Textiles (Quality Control) Order, 2022 dated 10.04.2023 with effect from 180 days after its publication is applicable on Geotextiles for use in various application during construction projects under IS 16391:2015 and IS 16392:2015 etc.

Further, IS 16391:2015 (Geotextile used in Sub-grade separation in pavement structures) which covers general and performance requirements for geo textiles used to prevent mixing of a sub grade soil and an aggregate cover material in pavement structures and IS 16392:2015 (Geotextiles for permanent erosion control in hard armor systems) which covers Geotextiles for permanent erosion control in hard armor systems and also this standard covers general and performance requirements for geotextiles used between energy absorbing armor systems and in-situ soil to prevent soil loss resulting in excessive scour and prevent hydraulic uplift pressures causing instability of the permanent erosion control system.

The CB of the importer provided the literature of the use case of the geotextile material which is required to assemble the final structure of "Defencell Mac" which will act as defensive barrier. The Defense Cell Mac as per the literature provided means a new range of protective galmac welded wire mesh Gabions lined with Geotextile and supplied in several standard sizes. Defencell Mac gabions are filled with earth, sand, or other locally available fill materials and provide ballistic protection. blast mitigation and HVM vehicle barriers. In view of the above facts, it appears that the imported goods are covered under the IS 16392:2015 i.e 'Geotextiles for permanent erosion control in hard armor system' and is mandatory in the instant case. However, importer has not been able to produce the BIS.

Further, Sh. Anil Kumar Soni, Charted Engineer was appointed to provide specification of the goods, use case and applicability of BIS on the imported goods and accordingly, Sh_Anil Kumar Soni, CE vide report dated 07.10 2024, provided a detailed clarification regarding the application of Geo Textile material in making portable and detachable protective galmac welded wire mesh galoons lined with Non-woven geotextiles. These gabions are filled with earth, sand or locally fill material which can be used for flood protection and storage of ammunition in bunkers/most remote places and armors against projectiles and also confirms that the imported material i.e. Non-Woven Geo Textiles attracts BIS IS 16392:201'5 in the instant case.

Under Section 17(1) of the Bureau of Indian Standards Act, 2016, prohibition has been imposed on manufacture, import, sale, storage etc., of the such goods/items without having the prescribed Standard Mark and without the prescribed license; and that the said prohibition has been imposed in public interest for the protection of human, animal or plant health, safety of the environment, and prevention of unfair trade practices. Moreover, the purpose for imposing BIS appears to be logical step insuring safety and security of defence gabion/defence cell mac.

Since, the importer has mis-classified the goods under CTH 56039490 instead of CTH 56039410 and also not able to produce the BIS under IS 16392:2015 and accordingly, it appears that the imported goods/items are mis-classified and prohibited in absence of BIS and thus, the Importer has contravened the provisions of Section 17 and Section 46(4) of the Customs Act, 1962 read with Foreign Trade Policy and provisions of other allied acts. Also, it appears that the Importer has violated the provisions of Section 46(4A) of the Customs Act, 1962 by importing goods/items which fall under the definition of "Prohibited Goods" as defined

In Section 2(33) of the Customs Act, 1962 and the same appears to be liable for confiscation under Section 111(d), 111(m).

The goods covered under BID of Entry No.5645441 dated 17.09.2024 and 5646657 dated 17.09.2024 are therefore, placed under seizure In terms of the provisions contained in Section 110 of the Customs Act, 1962 as the same are liable for confiscation under Section 111(d), 111(m) of the Customs Act, 1962.

THE BOMBAY TEXTILE RESEARCH ASSOCIATION

(Approved Body of the Ministry of Textiles, Govt. of India)
Lal bahadur Shastri Marg, Ghatkopar (West), Mumbai - 400086.
Phones : 022 - 6202 3636 / 6202 3600
Fax : 91-22-2500 0459 Email : btloffice@btraindia.com / info@btraindia.com
Website: www.btraindia.com

BTRA TEST LABORATORIES

TEST REPORT

Report Details : BTUTRIB2400048/TT/1/B/2024 ULR No : TC694124000000048 Date : 16-01-2024

Maccaferri Environmental Solutions Pvt.Ltd.
VPO-Pandoga Kariyan,Dist.& Tal.-Una
Una
Pincode : 177207
Contact Person : M.B.Haval

THE FOLLOWING SAMPLE(S) WAS/WERE SUBMITTED AND IDENTIFIED BY/ON BEHALF OF THE CUSTOMER AS:

Sample No	**: B2400048-1**	Product Description	: **DEFENCELL MAC GEOTEXTILE**
Received on	: **02-01-2024**	Total Number of Samples in Order	: 1
Testing Period	: **02.01.2024 To 13.01.2024**	Reference	: **Mace India/QA/2023/December/27 Date: 22.12.2023**
Despatched on	:	Sample Type	: **TT**
Project Name	:	Page	: **1/1**

TEST RESULTS

Thickness *(EN ISO 9863: 2Q16)*

Test Parameter	Result
Thickness (mm)	-
Pressure : 2 kPa	1.68

Tensile strength ,(kN/m) ***(ISO 10319-2015*****)**

Test Parameter	**Result**
Wide Width Tensile Strength (kN/m)	
Machine Direction	17.5
Cross Machine Direction	21.8
Elongation at maximum load(%)	

Machine Direction	77.3
Cross Machine Direction	75.3

Characteristic Opening Size *(ISO 12956-2010)*

Test Parameter	**Result**
Characteristic Opening Size ,(in mm)	BELOW 0.075

THE BOMBAY TEXTILE RESEARCH ASSOCIATION

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Website: www.btraindia.com
BTRA TEST LABORATORIES
TEST REPORT

Ideport Details : BTLJTR/B2400048/TT/1 /A/2024	ULR No : TC694124000000048F	date : 16-01-2024

Maccaferri Environmental Solutions Pvt.Ltd.
VPO-Pandoga Kariyan,Dist.& Tal.-Una
Una
Pincode : 177207
Contact Person : M.B.Haval

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Despatched on	:	Sample Type	: **TT**
Project Name	:	Page	: **1/1**

TEST RESULTS

Mass per square meter *(1509864 :2005*)

Test Parameter	**Result**
Mass (g/m^2')	283

CBR Puncture Strength (N) (*15012236-2006)*

Test-Parameter	**Result**
Static (CBR) Puncture Resistance (N)	3566

Cone Drop Test (Dynamic Puncture Test) *(ISO 13433-2006)*

Test Parameter	**Result**
Dynamic Perforation [Cone Drop] (mm)	28

Water Permeability *(ISO 11058-2019*)

Test Parameter	**Result**
Water Permeability@ WH=50mm (1/m^2/sec)	68.8

Comparison of DEFCEL GTX MAC vs IS 16392 :2015 & IS 16391

Date: 29th October 2024

Material Detail

Item Detail	DEFCEL GTX MAC19 T BEG 2.94X285
PO No	:4100009910 Dt- 05-07-24
Invoice No. Dt & Qty	:917, 920, 923, 925 Dt- 18-07-24 (134064 sqm)
	:935, 938, 939 Dt- 19-07-24 (92169 Sqm)
	: 942 Dt- 22-7-24 (33516 Sqm)

Parameter	Test Method	U.M.	Min Allow. Avg (Tolerance)	Observed values	Spec values as per is 16392 : 2015	Spec values as 'Der IS 16391
Mass per unit area	EN ISO	g/m2	210	283	Not	Not

	9864:2005				mention in standard	mention in standard
Thickness (at 2kPa)	EN ISO 9863 1:2005 I	Mn	1.5 (+10%)	1.6	0.40	0.40
Tensile Strength — MD	EN ISO 10319:2008	kN/m	13.5 (-1.45)	17.5	Not mention in standard	Not mention in standard
Tensile Strength — TD	EN ISO 10319:2008	kN/m	13.5 (-1.45)	21.8	Not mention in standard	of mention in standard
Tensile Elongation — MD	EN ISO 10319:2008	%	60 (±20)	77.3	Not mention in standard	Not mention in 'standard
Tensile Elongation — TD	EN ISO 10319:2008	%	60 (±20)	75.3	Not mention in standard	Not mention in 'standard
CBR Puncture Strength	EN ISO 12236:2006	N	2400 (-275)	3566	350	50
Cone Drop Test	EN ISO 13433:2006	Mm	26 (+5)	28	Not mention in standard	Not mention in standard
Apparent Opening Size (AOS)	EN ISO 12956:2010	µm	65 (±20)	Below 75	43	60
Permeability (H50)	EN ISO 11058:2010	I/m2s	55 (-17)	68.8	Not to mention in standard	0.02 I/m2 min
Pullout Interaction Coefficient, at 6 mm displacement, Normal load equal to 5 kPa, *Min*					0.8	0.8
Coefficient of Direct Shear at peak geotextile shear strength,					5	5

Normal load equal to 5 kPa, *Min*						
Resistance to installation damage, Percent retained Strength,*Min*					90	90
Ultraviolet stability at 500h, retained strength, percent of original strength, *Min*					70	70

RAPPORTO DI PROVA E CONFORMITA
GEOTESSILI

DATA **16/07/2024**	CLIENTE o PRODUTTORE OFF. MACCAFERRI ITALIA SRL	LOTTO 1238/24
TIPO: **DEFCELL MAC A 19**		
OSSERVAZIONI:		
REQUIRED CARACTERISTICS		**TEST RESULTS**
Mass UNI EN 9864	>220	273,8
Thikness EN ISO 9863-1	> 1,37	1,90
Tensile Strength MD Elongation UNI EN ISO 10319	13,5 KN/m (-1,5) 75% (-10%)	17,12 kN/m (min 15,72) 86,63% (min 70,83)
Tensile Strength CMD Elongation UNI EN ISO 10319	13,5 KN/m (-1,5) 75% (-10%)	24,55 kN/m (min 21,59) 87,50% (min 78,50)
Picture Test UNI EN 12236	2,4 KN (-0,3)	3,14 kN (min 2,93

Dinamic Puncture Test UNI EN 13433	17 mm (+5,0)	14,5
Trapezoidal Tensile MD ASTM D 4533	356 N (-45)	364 N (min 323)
Trapezoidal Tensile CMD ASTM D 4533	356 N (-45)	508 N (min 433)
Grab Test MD Elongation ASTM D 4632	934 N (-134) 80% (75%)	951 N (min 845) 82,50% (min 76,67)
Grab Test MD Elongation ASTM D 4632	934 N (-134) 80% (75%)	1292 N (min 12,19) 83,89% (min 76,67)
Permeability Astm 4491 EN ISO 11058	1,1 1/s	1,31

ANNEX 11

(*Item* 7.1)

COMMENTS ON IS 16090 : 2013 'GEO-SYNTHETICS - GEO-TEXTILES USED AS PROTECTION (OR CUSHIONING) MATERIALS - SPECIFICATION'

Commentator: Shri Ratnakar Mahajan, Maccaferri Environmental Solutions Private Limited, Gurugram

Comment:

Dear Sir,

Please find inputs on the standard circulated.

Please feel free to contact me for any clarifications.

Sr. No.	Clause	Suggestions	Remarks
1	FOREWORD "GRI Test Method — GT 12 (b) : 2008"	Refer to latest version available (rev.3 3/£/2016)	
2	Clause 4.2	4.2 seems to be a repetition of par 4.3	
3	Clause 4.3	UV performance should be correlated not to the percentage of the stabilizers added during the manufacturing process but to the performance in terms of resistance against UV measured by the retained tensile strength after the relevant UV test according to the relevant standard (ASTM D 4355_EN ISO 12224)	

4	Table 1 “CBR puncture resistance”	Requirements seem to be quite conservative. Experienced manufacturer using good quality fibers can meet easily the minimum values reported in the table. Table is a copy paste of the table included in the correspondent GRI standard.	
5	Clause 7 “LDPE film of minimum thickness of 40µ”	Too specific in my opinion. I would stay more generic as per the correspondent GRI standard (*“Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.”)*	
6	Clause 8 “Geo-textile product sample approximately 1 m2 or larger”	Number and size of the samples to be submitted to the eventually required conformance tests shall be conform to the relevant standards for sampling (ASTM D4354) and conformance testing (ASTM D 4759)	
7	Clause 9.1 “microscopic and confirmatory chemical tests prescribed in IS 667”	?! To be checked	

8	Clause 9.1 “Each shipping document shall include documentation certifying that the material is in compliance with this standard”	TDS reporting values meeting or exceeding values as per the table included in the present standard shall be considered sufficient in my opinion. No need for an additional document.	
9	Clause 9.2 “A roll puller, nylon strap, or rope can be used to unload geotextile rolls from an enclosed trailer by inserting into the roll core and dragging the roll to the edge of the truck bed and down to the ground surface. Nylon straps or ropes may also be wrapped around the geotextile roll using a slipknot. Again the roll is dragged to the edge of the truck and down to the ground surface.”	It seems to be a repetition	
10	Clause 9.4.1 “The paving fabric shall be kept dry and wrapped such that it is protected from outside weather during shipping and storage.”	Not only paving NW...	
11	Clause 9.4.2	?!	
12	Clause 9.4.5	It seems to be a repetition	
13	Clause 9.4.8	Again it seems to be a repetition	

Commentator: Shri Rajendra Ghadge, Garware Technical Fibers, Pune

Comment:

Kind attention : Mr. Himanshu, No any comments from our side for this standard. Only one sugges on. The Trapezoid Tear Values to be wri en in newton instead of kN. Thanks

Commentator: Shri V. N. Gore, In personal capacity

Comment:

Dear Shri Gupta,
I fully agree with you. The standard 16090:2013 may have to be virtually rewritten taking note of the advances in the technology, manufacturing processes as also the field experience generated over the last 10 years of Geomembrane (GM) applications for seepage control with or without protection.

The other members must have already sent their observations/ comments by the deadline of 30/10/24 which I could not meet as I was fully tied up with other prior engagements. Nevertheless, I would like you to consider my observations/ suggestions below. I also feel that it may be goo, if possible to plan a brain storming to discuss on all the comments/observations /suggestion and let the task of revision/rewriting of 16090 be planned accordingly.

My observations/ suggestions are:

a) Scope:
   ------1.1 and 1.2 should mention to add lined fresh water storage structures (small, medium and large) lined by geomembrane serving the "Industrial and Agriculture Sectors". The "Note under 1.1 and 1.2" to mention other factors/agents e.g. rodents and other burrowing animals, etc. as well that often compromise geomembrane performance.

Scope at 1.3 and 1.4 may be retained.
-------The status of 1.5 needs a thorough review presuming that it was published as was planned in 2013 and is currently in use. b) Table 1:------ The protection table 1 currently over rely on N.W. Geotextile. I find that the exclusive use N.W. geotextile beyond 300-400 GSM becomes suboptimal. The standard needs to consider use of "composites" to draw upon functional benefits of two or more materials used in

conjunction with the needle punched nonwoven. There are several options of composites; I am listing only a few below:
1. A 300gsm N.W suitably bonded to say 90gsm slit tape woven would yield puncture and tear resistance comparable to 600-800 gsm N.W. geotextile.
2. A tailor made geocell of required depth and properties filled with industrial wastes e.g. flyash, quarry dust, graded construction debris etc.,
3. A cement impregnated N.W. geotextile specifically deployed to counter damages caused by rodents, crabs etc., ------ Finally, the table1 needs to be arranged in to parts to prescribe types of protection materials/ products based on e.g. GMs up to 500 microns and GMs of 1000microns and above as also reinforced GMs of equivalent properties. The table should also prescribe separately the protection for GMs installed on the bed and slopes. Let me have your response though I fully recognize that I am off the deadline.

Commentator: Smt. Soumita Chowdhury, IJIRA, Kolkata

Comment:

Sir,

Thickness is an important factor for better performance of geomembrane, hence thickness parameter may be included into the standard.

Similarly we can also add some idea about the use of specific geo membranes (Type - 1 to Type 6) according to the site condition (soil type, groundwater levels, temperature fluctuations, and potential exposure to chemicals or UV radiation etc).

With best regards,

Soumita Chowdhury
Scientist
Indian Jute Industries Research Association

ANNEX 12

(*Item* 8.1)

AGENDA OF NEXT MEETING OF ISO TC 221 'GEOSYNTHETICS'

(*Attached separately*)

ANNEX 13

(*Item* 8.2)

NEW WORK ITEM PROPOSAL ON GEOSYNTHETIC CEMENTITIOUS MATS (GCCMS) AND BARRIERS (GCCBS)

Outline of Proposed ISO Technical Specification for GCCM Durability.

1.0 Introduction

Geosynthetic Cementitious Mats (GCCMs) and Barriers (GCCBs) comprise a layer of cementitious material contained within one or more geosynthetic materials that harden on hydration.
GCCMs and GCCBs differ from most geosynthetics because their properties change on hydration from flexible to rigid. There are no ISO standards to specifically assess cementitious material performance within GCCMs and GCCBs.

GCCMs and GCCBs are also unlike most geosynthetics as instead of being buried in service, they are used for surface erosion control (GCCM) and containment (GCCB) applications and are therefore exposed to UV, flexural bending (loading) and abrasion.

This Technical Specification covers the test methods used to assess GCCM and GCCB durability for exposed applications.

2.0 Scope

This International Technical Specification specifies the methods for preparation and testing of GCCMs and GCCBs for durability testing.

3.0 References

ASTM C1353/C1353M Standard Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic Using a Rotary Platform Abrader

ASTM D8030/ASTM D8030M-23 Standard Practice for Sample Preparation for GCCM
ASTM D8058-23 Standard Test Method for Determining the Flexural Strength of a GCCM Using the Three-Point Bending Test
EN 12224:2000 Geotextiles and geotextile related products – Determination of the resistance to weathering [UV 5h @ 50C, 1h water spray @25C, 50MJ/m^2]
EN 12467:2012 +A2:2018 Fibre-cement flat sheets – Product specification and test methods [section 7.4.1 freeze-thaw]
EN14414:2004 Geosynthetics – Screening test method for determining chemical resistance for landfill applications

4.0 Terms

4.1

[ISO:] Geosynthetic cementitious composite (GCC) – Factory produced geocomposite in the form of a sheet, consisting of cementitious material contained within one or more geosynthetics.
[ASTM:] Geosynthetic cementitious composite mat (GCCM) – a factory-assembled geosynthetic composite consisting of a cementitious material contained within a layer or layers of geosynthetic materials that become hardened when hydrated [for erosion control]
[ASTM:] Geosynthetic cementitious composite barrier (GCCB) – a composite material consisting of a geosynthetic barrier bonded to an integral GCCM protective cover layer. The geosynthetic barrier component of adjacent material must be seamed to reduce or prevent the flow of fluid through the construction [for containment]

5.0 Principle

- All specimens must be cured according to ASTM D8030, hydrated for 1 day and stored for a further 27 days [28 days in total from initial hydration]
- Unless stated otherwise, index testing shall be to ASTM D8058 recording the Initial Flexural Strength (IFS) [cementitious material durability] and Final Flexural Strength (FFS) [geosynthetic material durability]. Divide the IFS/FFS of the exposed specimens by the IFS/FFS of the control specimens. For GCCB's, remove the thickness of the geosynthetic barrier layer from the IFS calculation.
- Durability Tests:
  - Weathering (UV) testing: use EN 12224 and use ASTM D8058 to assess retained strength
  - Abrasion: use ASTM C1353, modified to record the depth of the cementitious material layer wear for every 1,000 cycles. Record the total number of cycles to failure. ASTM D8058 does not apply
  - Freeze-Thaw testing [applicable climates only]: Follow EN 12467 section 7.4.1 and use ASTM D8058 to assess retained strength

    - Chemical resistance [relevant applications only]: Follow EN14414 using the chemical/liquid specific to the project/application and use ASTM D8058 to assess retained strength.
- For durability testing of the geosynthetic barrier component of GCCBs, consult the relevant geosynthetic barrier durability standard, such as BS EN 16993:2018 Geosynthetic barriers – Characteristics required for use in the construction of storage lagoons, secondary containment (above and below ground) and other containment applications for chemicals, polluted water and produced liquids.

ANNEX 14

(*Item* 8.3)

USER MANUAL FOR ACCESSING IRD PORTAL

(*Attached separately*)