

Dated:16th March 2026

CIRCULAR

To

1. The Chief Secretaries of all the State Governments/ UTs.
2. The Principal Secretaries/ Secretaries of all States/ UTs Public Works Department/ Road Construction Department/ Highways Department (dealing with National Highways and other centrally sponsored schemes).
3. The Chairman, National Highways Authority of India, G-5 & 6, Sector-10, Dwarka, New Delhi-110 075.
4. The Managing Director, NHIDCL, World Trade Centre, New Delhi-110029.
5. The Director General (Border Roads), Seema Sadak Bhawan, Ring Road, New Delhi-110 010.
6. All Engineers-in-Chief and Chief Engineers of Public Works Department of States/ UTs/ Road Construction Department/ Highways Departments (dealing with National Highways and other centrally sponsored schemes).
7. The Secretary General, Indian Roads Congress.
8. The Director, IAHE, Noida, UP.
9. All CE-ROs, ROs and ELOs of the Ministry.

Subject: Standard Operating Protocol (SoP) for Use of Reinforced Soil (RS) Wall Technology in National Highways (NHs) Projects- Reg.

Madam/Sir,

Reinforced Soil (RS) Wall Technology is extensively used to retain high embankment approaches to structures in National Highways (NHs) projects as it requires least land. While a majority of these structures are performing well, varying levels of distress and performance issues have been observed in a few cases due to several reasons, including the following:

- Lack of knowledge and expertise: Inadequate understanding of RS wall system design principles, construction techniques, quality control and maintenance requirements among site engineers.
- Design and detailing deficiencies: Deviations in the design process, such as insufficient design calculations (settlement calculations and global stability checks often skipped), improper/inadequate geotechnical investigations and insufficient drawing detailing for construction.
- Construction deficiencies: Poor workmanship, use of substandard materials, negligence at site engineers' level, or failure to follow proper construction procedures.
- Inadequate maintenance: Inadequate maintenance, inspection and timely resolution.

To address these concerns and to have long-term performance durability of RS Wall structures, need was felt to have a Standard Operating Protocol (SoP) for selection,

investigation, design and construction including robust quality control measures. Accordingly, Ministry has funded a research scheme to IIT Delhi to study the modes of premature distresses/collapse and causative factors thereof. Further, NHAI has also conducted an open house discussion on this subject and an expert committee has been constituted.

2. On the basis of research findings, recommendations of the expert committee, experienced gained over the years, issues encountered and feedback/suggestions received from the stakeholders a SOP has been prepared. SoP includes quantum of sub-soil investigations, selection criteria matrix for RS Wall, good design and construction practices including Quality Assurance & Quality Control (QA&QC). This SoP is intended to function as a practical field-ready tool, enabling uniform practices, consistent quality and enhanced accountability across all RS wall projects.

3. Salient points of the SoP extracted from the enclosed detailed SoP at Appendix are as under:

3.1 **Geotechnical Investigations:** Boreholes spacing, number and depth are as under:

Sl. No.	Height/ Ground Conditions	Number/ Spacing/ Location of Boreholes	Minimum Depth of Boreholes/ Soundings
1.	Wall Height > 10m or poor ground condition	50 m	Least of the following: a) Four times the height of the reinforced soil structure b) Two times the average width of the embankment c) 30 m
2.	Wall Height < 10m or other than poor ground condition	100 m	
3.	RS closure wall or true /load bearing abutments	Minimum two boreholes (One borehole close to the ends of the reinforced soil walls)	

3.2 **Selection Criteria for RS Wall:** Full height RS wall should be selected in general. The permissible height of the RS Wall should be on the basis of sub-soil parameters as detailed below:

S. No.	Ground Condition / Parameters		Permissible Height of RS Wall	Recommended Tests	Suggested Ground Improvement Measures
1	SPT-N ≤ 2 or UCS ≤ 25 kPa or Cu ≤ 12 kPa	If depth from original ground level (OGL) ≤ 3.0m	RS Wall may be adopted after full depth replacement with acceptable fill.	Detailed geotechnical investigations including: 1 Field vane shear test/ Laboratory vane shear test on undisturbed sample (UDS) in case of soft clays. 2. Consolidation tests for coefficient of consolidation (C_v),	
		If depth from original ground level (OGL) > 3.0m	Construction of RS Wall shall be avoided. In such case, Option of Viaduct may be adopted.		

S. No.	Ground Condition / Parameters	Permissible Height of RS Wall	Recommended Tests	Suggested Ground Improvement Measures
			initial void ratio(e_0), compression index (C_c) and other consolidation parameters. Hydrological & scour depth assessment in case of flood plain/erosion prone areas.	
2	2 < SPT-N ≤ 4 or 25 kPa < UCS ≤ 50 kPa or 12 kPa < C_u ≤ 25 kPa	Height of RS wall may be restricted upto 6.0m.	-do-	1. Replacement with granular soil (if clay depth < 3.0 m)
3	4 < SPT-N ≤ 8 or 50 kPa < UCS ≤ 100 kPa or 25 kPa < C_u ≤ 50 kPa	Height of RS wall may be restricted upto 8.0m.	-do-	2. Stone columns 3. Prefabricated vertical Drains (PVDs)
4	SPT-N > 8 (or C_u > 50 kPa) but Waterlogged area, Marshy land and zone of sea backwater, etc.	Height of RS wall may be restricted upto 10.0m.	-do-	4. Basal reinforcement / Basal mattress
5	Other cases	Design Height of RS wall may be restricted upto 15.0m (including embedded depth).	As per Clause 10.1 a) of IS:18591.	

Note:

- SPT test shall be conducted just after recession of monsoon to represent the weakest sub-soil condition.
- Appropriate ground improvement techniques shall be selected based on site conditions. Ground improvement shall be carried out as per design and extend beyond toe of the wall.
- Where stage construction is adopted, the increase in shear strength specified for each stage has to be checked in the field, by vane shear tests or laboratory tests on undisturbed samples. Work on next stage filling can be permitted only after it is ascertained that the strength gain needed for building the next stage has been reached.

- Two staged constructions may be adopted where the structure is constructed on weak soils, being treated by PVDs as ground improvement techniques. The reinforced soil structure is first constructed with soft/compressible fascia systems. The deformations shall be monitored. After consolidation settlements have taken place, the soft facing may be covered with hard fascia with appropriate detailing to cater to further minor deformations.

3.3 **Internal Drainage System:** An aggregate drainage bay of minimum 600 mm width at the back of the facing shall be provided.

3.4 **Selection of Pavement Type/Layer:** Pavement above RS walls shall be flexible without using Cement Treated Base (CTB) layer. Rigid PQC pavements shall not be used.

3.5 **Reinforcement:** Field pullout testing of geosynthetic reinforcement shall be carried out to validate the soil-reinforcement interaction coefficient adopted in design, using the proposed geosynthetic, backfill and actual field compaction methodology.

3.6 **Gap Slab:** Gap slab type structure shall be avoided in all respect, by providing wall type abutment. In case of Gap slab is unavoidable, the maximum length of gap slab should be restricted to 2.0m.

3.7 **Warranty from RS Wall System Provider:** The system provider shall furnish 30 years warranty period.

3.8 **Involvement of System Provider during Execution:** Contractor/Concessionaire shall ensure signing of agreement between the Contractor/Concessionaire and Technology Provider before use of RS wall and Geosynthetic material in NH Project in compliance with Para 4.7 MoRT&H Policy Circular EFile No.RW/NH-34049/01/2020-S&R (P&B) pt. (Computer No.-207229) dated 20th September 2024. The agreement shall have the provision of involvement of the Technology Provider during execution from start to end of the RS wall construction. Technology provider shall be responsible for all aspects of RS wall construction including accuracy of geotechnical investigations, design, supervision and ensuring quality of construction including fill material.

4. This circular shall be made applicable for all DPR consultancy works for NHs projects which are issued on or after 30 days after the date of issue of this circular.

5. ROs and PDs of PIUs shall also ensure that Project Reports are in compliance with these provisions.

6. It is requested that the contents of the circular may be brought into the notice of all concerned for needful compliance.

7. This issues with the approval of the Competent Authority.

Yours sincerely,
Bidur Kant Jha
16-03-2026
(Bidur Kant Jha)
Director
(New Technology for Highway development)
For DG (RD) & SS

Enclosure: Appendix- Detailed SoP for RS Wall (63pages).

Copy to:

1. All CEs in the Ministry of Road Transport & Highways
2. All ROs of the Ministry of Road Transport & Highways
3. All CE(NH) of PWD/R&B dealing with National Highways
4. Technical circular file of S&R (P&B) Section
5. NIC-for uploading on Ministry's website under "What's new" & "Comprehensive Compendium Circulars with CODE 1100.37.

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6. Sr. PPS/ PPS to AS&FA
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8. Sr. PPS/ PPS to JS (RT&MVL)/ JS (EIC) / JS (Logistics)/ JS (NHIDCL)

1. Introduction

Reinforced soil retaining wall (RS wall/ RE wall) are being extensively used in highway projects in India as it requires least land acquisition. While a majority of these structures are performing well, varying levels of distress and performance issues have been observed in a significant number of cases due to several reasons, including the following.

1. Lack of knowledge and expertise: Inadequate understanding of RS wall system design principles, construction techniques, quality control and maintenance requirements among site engineers.
2. Design and detailing deficiencies: Deviations in the design process, such as insufficient design calculations (settlement calculations and global stability checks often skipped), improper/inadequate geotechnical investigations, and insufficient drawing detailing for construction.
3. Construction deficiencies: Poor workmanship, use of substandard materials, negligence at site engineers' level, or failure to follow proper construction procedures.
4. Inadequate maintenance: Inadequate maintenance, inspection, and timely resolution.

Combinations of these factors can occur in complex ways during construction and lead to an increased likelihood of distress/failure. To address these concerns, it is essential to develop Standard Operating Protocol (SoP), implement robust quality control measures, ensure adequate training of site engineers, and conduct regular inspections and maintenance of RS walls.

The expert committee recommended the following actions/protocols which are intended to function as a practical field-ready tool, enabling uniform practices, consistent quality, and enhanced accountability across all RS wall projects.

2. Various Elements of RS Wall

2.1 Reinforced soil walls are composite structures wherein compacted fill is internally stabilized by placing discrete horizontal tensile reinforcements at design locations during construction. The major components of Reinforced Soil (RS) walls used for highways (See Figure 1) are:

1. Foundation
2. Facing panel and associated connection system
3. Fill Material
4. Reinforcement
5. Drainage bay
6. Levelling pad, Bearing pad, Crash barrier, Friction slab and Other Accessories

2.2 Each component has a specific intended function, and hence requires use of a specific type of material. Each component has multiple design options for the designer to choose from. Hence RS walls as retaining structures are designer-friendly.

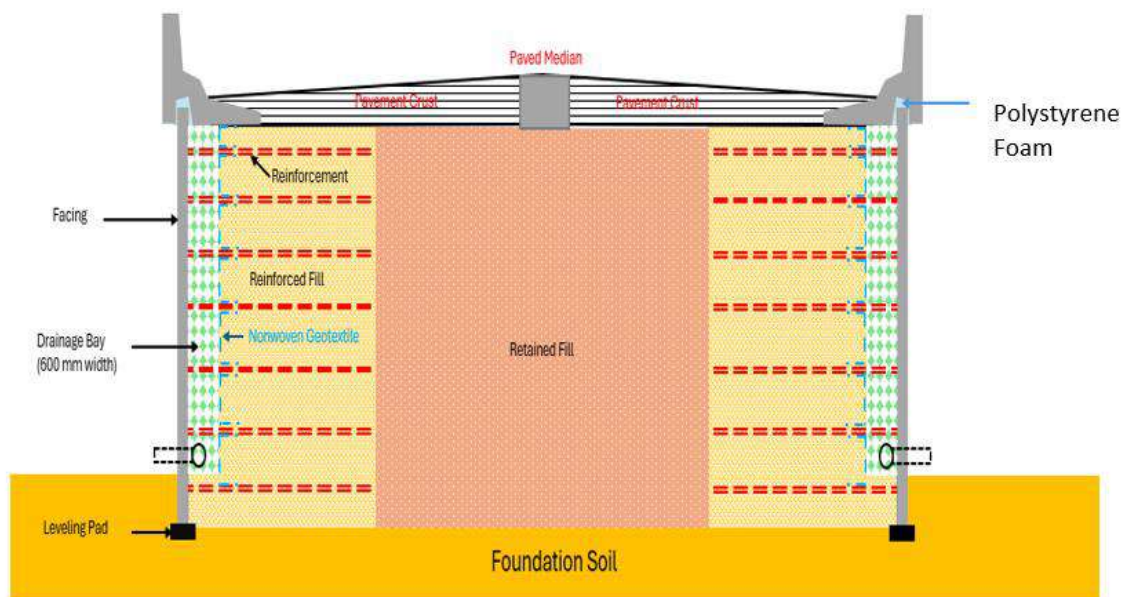
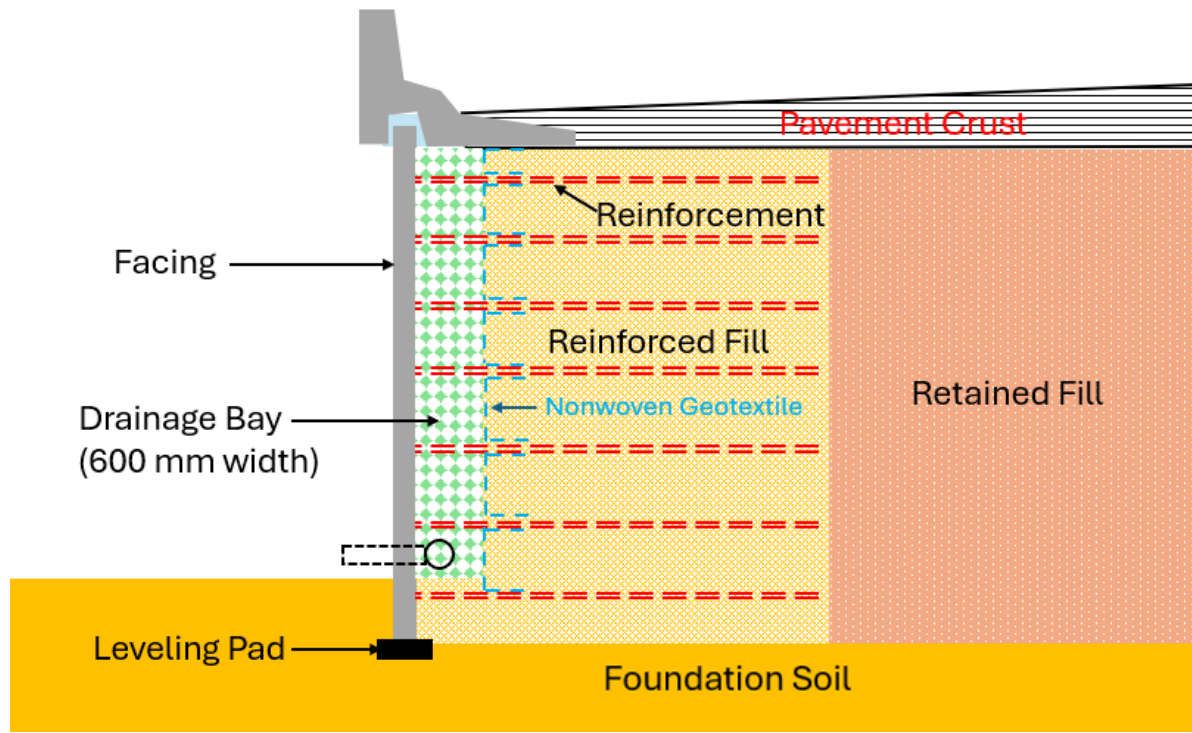


Figure 1: Elements of RS Walls

3. Foundation

3.1 Geotechnical Investigations

3.1.1 Boreholes spacing, number and depth are given in table below:

Sl. No.	Height/ Ground Conditions	Number/ Spacing/ Location of Boreholes	Minimum Depth of Boreholes/ Soundings
1.	Wall Height > 10m or poor ground condition	50 m	Least of the following: a) Four times the height of the reinforced soil structure b) Two times the average width of the embankment c) 30 m
2.	Wall Height < 10m or other than poor ground condition	100 m	
3.	RS closure wall or true /load bearing abutments	Minimum two boreholes (One borehole close to the ends of the reinforced soil walls)	

3.1.2 Poor ground condition are:

1. Uncontrolled/unsuitable fills like loosely dumped soils, debris, waste materials;
2. Organic soils;
3. Weak and compressible fine-grained soils;
4. Expansive soils;
5. Loose coarse-grained soils; and
6. Strata with cavities

3.1.3 Geotechnical parameter for poor ground condition are mentioned in table below:

○ Cohesive Soils

Consistency	Unconfined Compressive Strength (kPa)	SPT Value (N)	SCPT Value (kPa) (acc. to Akca (2003))
Very Soft	<25	0-2	0-400
Soft	25-50	2-4	400-800
Medium	50-100	4-8	800-1600

○ **Very loose /Loose sand**

Consistency	SPT-N	SCPT (qc in MPa)
Very Loose sand	0-4	< 3
Loose sand	4-10	3-6

Note:

1. Boreholes shall be located within the footprint of the reinforced soil zone, preferably one borehole each close to the ends of the reinforced soil wall.
2. At locations where rock/weathered rock is encountered at a shallow depth, which can safely support the reinforced soil structure, test pits may be used instead of boreholes, subject to the approval of the engineer.

For Detailed Geotechnical Investigation refer Section 2 IS 18591:2024.

3.1.4 Select field tests as per the Table given below based on strata. Laboratory tests: follow relevant BIS standards.

Sl. No.	Design Limit State	Property	Type of soil	Suitable Tests	Remarks
1.	Bearing capacity/ global capacity	Effective angle of shearing resistance (ϕ')	Sands	SCPT, SPT	
2.			Gravels	SPT	
3.			Residual Soils	SPT	
4.		Undrained shear strength	Very soft/ soft clays/ silts	FVST, SCPT	Driving the sampler using impact shall be avoided.
5.			Medium stiff to stiff clays/ silts	SCPT, SPT, Undisturbed sample (UDS)	
6.			Very stiff to hard clays/ silts	SCPT, SPT	
7.	Settlement	Drained modulus (E')	Sands	SCPT, SPT	
8.			Gravels	SPT	

Sl. No.	Design Limit State	Property	Type of soil	Suitable Tests	Remarks
9.			Residual Soils	SPT	
10.		Undrained modulus (E_u)	Clays/ silts	SCPT, SPT	
11.		$e_0, C_c, C_r, \sigma'_p, C_v$	Clays /silts	Consolidation tests on Undisturbed sample (UDS).	Correlations with liquid limit, water content etc. are not reliable
12.	Liquefaction		Sands	SPT, SCPT	

Where

SCPT = Static cone penetration test;

SPT = Standard penetration test;

FVST = Field vane shear test;

UDS = Undisturbed sample;

e_0 = Initial void ratio;

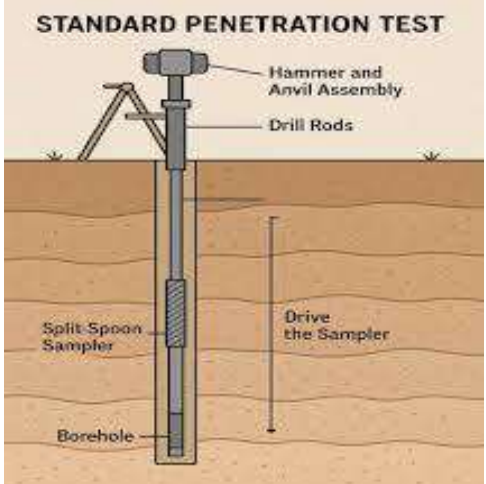
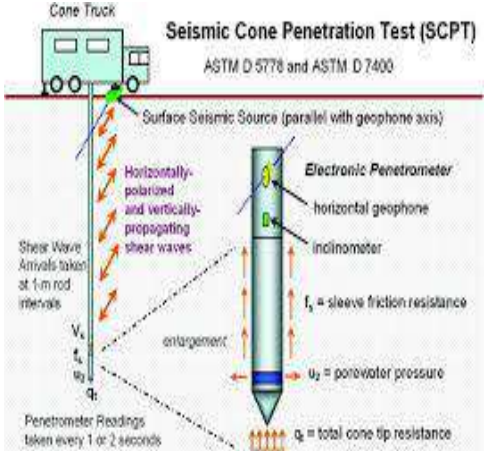
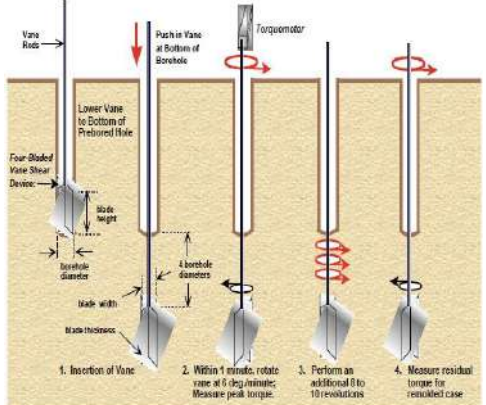
C_c = Compression index;

C_r = Recompression index;

σ'_p = Pre-consolidation pressure; and

C_v = Coefficient consolidation in vertical direction.

Summary of Geotechnical Field Tests

Test	Primary Measurement	Best Suited For	Key Engineering Parameters	Visual Diagram
SPT	Blow count (N-value)	Sands and stiff clays	Density, liquefaction potential, bearing capacity.	 <p style="text-align: center;">STANDARD PENETRATION TEST</p>
SCPT	Tip resistance (q_c) & Sleeve friction (f_s)	Sands, silts, and soft clays	Soil stratigraphy, shear strength, and pile capacity.	 <p style="text-align: center;">Seismic Cone Penetration Test (SCPT) ASTM D 5778 and ASTM D 7400</p>
FVST	Torque	Soft to medium clays	Undrained shear strength (s_u) and sensitivity.	

Note:

1. The above-mentioned minimum investigations are mandatory at DPR stage. The borehole location shall be geotagged and test checked by PD/representative of Authority. These geotagged reports shall form part of bidding document and form baseline (minimum requirement) for design of structures & RS walls.
2. Concessionaire/Contractor shall perform Geotechnical investigation at its own and accordingly, RS wall should be designed. Additional ground improvement be undertaken by the Concessionaire/Contractor at its own cost.
3. AE/IE must provide inputs of a geotechnical expert for 01 year on full time basis (During Development period 06 months; Construction period 06 months) and 100% sub-soil exploration certification.
4. NHA Empowered agencies may be utilized for quality geotechnical investigations.

4. RS Wall Type Selection

4.1 Prefer full-height RS walls

4.2 Avoid partial height RS walls. In exceptional cases where partial height RS wall is unavoidable, SOP (given in **Annexure-I**) shall be strictly followed.

4.3 **RS wall on soft clay**

In area of large deposit of soft soil, the height of RS wall may be restricted as per table given below:

S. No.	Ground Condition / Parameters		Permissible Height of RS Wall	Recommended Tests	Suggested Ground Improvement Measures
1	SPT-N ≤2 or UCS ≤25 kPa	If depth from original ground level (OGL) ≤ 3.0m	RS Wall may be adopted after full depth replacement with acceptable fill.	Detailed geotechnical investigations including: 1 Field vane shear test/ Laboratory vane shear test on undisturbed sample (UDS) in case of soft clays. 2. Consolidation tests for coefficient of consolidation (C _v), initial void ratio(e ₀), compression index (C _c) and other consolidation	-
	or Cu ≤12 kPa	If depth from original ground level (OGL) > 3.0m	Construction of RS Wall shall be avoided. In such case, Option of Viaduct may be adopted.		

S. No.	Ground Condition / Parameters	Permissible Height of RS Wall	Recommended Tests	Suggested Ground Improvement Measures
			parameters. Hydrological & scour depth assessment in case of flood plain/erosion prone areas.	
2	2 < SPT-N ≤ 4 or 25 kPa < UCS ≤ 50 kPa or 12 kPa < C _u ≤ 25 kPa	Height of RS wall may be restricted upto 6.0m.	-do-	1. Replacement with granular soil (if clay depth < 3.0 m) 2. Stone columns 3. Prefabricated vertical Drains (PVDs)
3	4 < SPT-N ≤ 8 or 50 kPa < UCS ≤ 100 kPa or 25 kPa < C _u ≤ 50 kPa	Height of RS wall may be restricted upto 8.0m.	-do-	4. Basal reinforcement / Basal mattress
4	SPT-N > 8 (or C _u > 50 kPa) but Waterlogged area, Marshy land and zone of sea backwater, etc.	Height of RS wall may be restricted upto 10.0m.	-do-	
5	Other cases	Design Height of RS wall may be restricted upto 15.0m (including embedded depth).	As per Clause 10.1 a) of IS:18591.	

Note:

- SPT test shall be conducted just after recession of monsoon to represent the weakest sub-soil condition.
- Appropriate ground improvement techniques shall be selected based on site conditions. Ground improvement shall be carried out as per design and extend beyond toe of the wall.
- Where stage construction is adopted, the increase in shear strength specified for each stage has to be checked in the field, by vane shear tests or laboratory tests on undisturbed samples. Work on next stage filling can be permitted only after it is ascertained that the strength gain needed for building the next stage has been reached.
- Two staged constructions may be adopted where the structure is constructed on weak soils, being treated by PVDs as ground improvement techniques. The reinforced soil structure is first constructed with soft/compressible fascia systems. The deformations shall be monitored. After consolidation settlements have taken place, the soft facing may be covered with hard fascia with appropriate detailing to cater to further minor deformations.

5. Fill Material

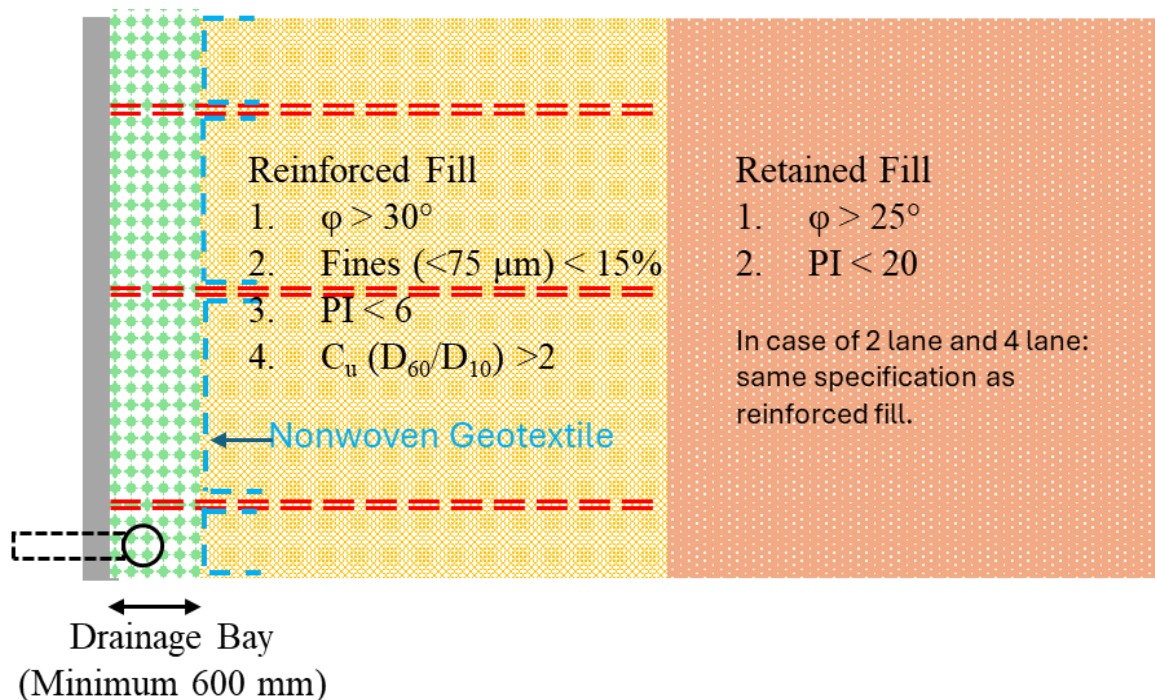


Figure 2: Schematic showing different fills in a reinforced soil structure

5.1 Reinforced fill soil shall conform to Table given below

Sl. No.	IS Sieve Size	Percent Passing	Method of Test, Ref. to	Remarks
1.	75 mm	100	IS 2720 (Part 4)	Plasticity index should be less than 6, Drained angle of internal friction should not be less than 30°. C_u should be greater than 2.
2.	425 microns	60 to 90		
3.	75 microns	0 to 15		

Note:

1. Maximum particle size for fill materials be reduced to 19 mm for geosynthetics and epoxy and PVC coated steel reinforcements.
2. The materials shall be substantially free of shale or other soft, poor durability particles. The material shall have a magnesium sulphate soundness loss of less than 30 percent after four cycles or a sodium sulphate value less than 15 percent after five cycles [soundness test as per IS 2386 (Part 5)].

5.2 Pond ash (commonly called as flyash)

Pond ash shall conform to points given below and shall be obtained from single source for given structure.

1. Pond ash used for reinforced fill and retained fill shall be free-draining and shall have $PI < 6$ and $C_u > 2$. It is recommended to use pond ash with MDD greater than 10 kN/m³ [IS 2720 (Part 8)]. The minimum angle of friction of pond ash shall be 30° [IS 2720 (Part 11)].
2. Even if the pond ash material does not meet the gradation criteria for backfill/ reinforced material as per Clause 5.1, this criterion is relaxed, considering high shear strength and good permeability characteristics of pond ash or bottom ash.

5.3 Retained fill

- If the reinforced fill material is pond ash same material must be used for reinforced fill.
- The retained fill in case of 2 lane and 4 lane highway project, where total width is not significant shall be of same specification as reinforced fill.
- In case reinforced fill and retained fill are different. The retained filled should be $\phi > 25$, $PI < 20$.

- Earth pressure acting on reinforced fill is more due to less ϕ value of retained fill. Therefore, alternate fill option of **Fig 2B** should be adopted.
- Drainage should be ensured by providing drainage bay between retained and reinforced fill.

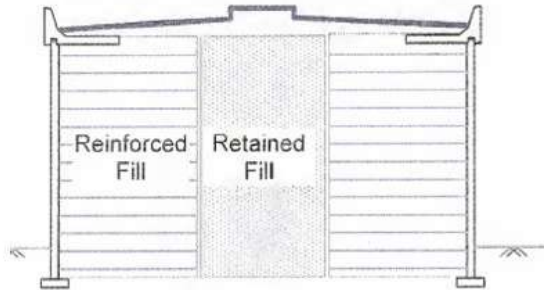


Fig. 2 A
More Earth Pressure

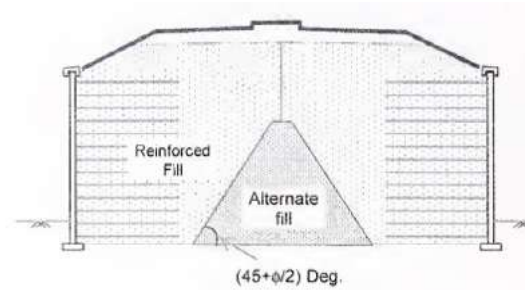
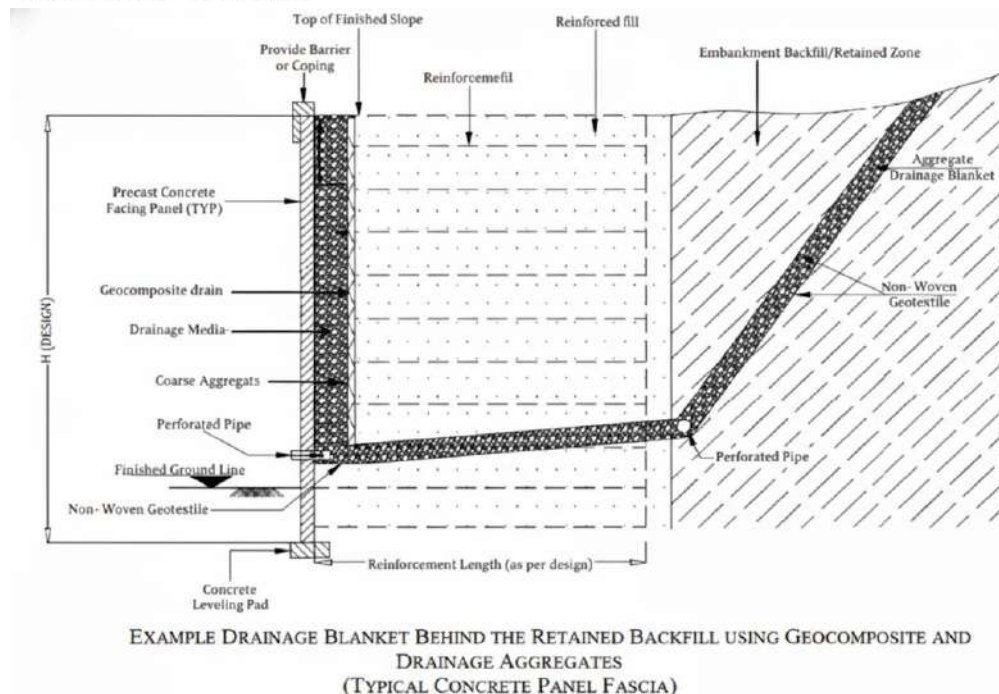


Fig. 2B
Less Earth Pressure



5.4 Under no circumstances, multiple fill materials should be allowed within a given stretch of wall.

6. Drainage Requirements

6.1 RS structures are not designed for hydrostatic pressures. Therefore, proper drainage shall be ensured.

There are two types of drainage:

1. Internal Drainage System
2. External Drainage System

6.2 Internal Drainage System

- A drainage bay of minimum 600 mm width at the back of the facing shall be provided as an adequate drainage measure.
- A non-woven geotextile shall be provided as a separation/filtration layer between the drainage aggregates and the reinforced fill material.
- Gradation Requirements for Drainage Bay

Sl. No.	Sieve Opening Size (mm)	Percentage Finer(%)	Remarks
1.	37.5	90 to 100	Drainage material shall be as per IS 18591:2024.
2.	20.0	80 to 100	
3.	12.5	0 to 20	

- **Slotted Drainage Pipe (SDP):**
 - The aggregate drainage bay must be connected to a longitudinal slotted/perforated drainage pipe of diameter 150 mm with outlet spacing 20-30 m. The PVC pipe shall conform to IS 15328. Longitudinal pipe shall be 200 mm above the ground level, so that the collected water is drained out of the structure.
 - The drainage pipe should have adequate slots/perforations for intake of water and should be wrapped with geotextile filter.
 - The longitudinal slotted drainage pipe should drain the collected water out of the RS wall at regular intervals by using a T-connection.
 - The third limb of the T-connection should pass through the sleeve hole in the facing and drain out on the front side of the toe into a local drainage system.

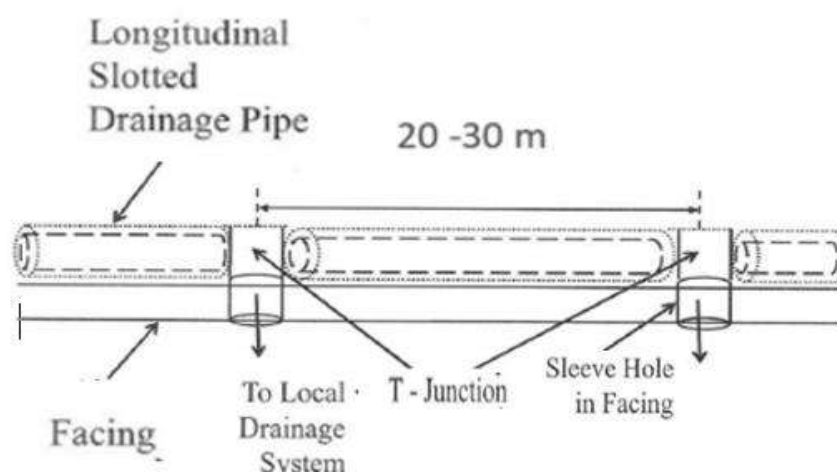


Figure 3: Longitudinal slotted drainage pipe with T-junction & exit through facing

- **Pavement above RS walls shall be flexible without using Cement Treated Base (CTB) layer. Rigid PQC pavements shall not be used.**
- Medians above RS walls shall be fully paved (with cement concrete underlined by impermeable membrane) to prevent water ingress.
- Drain at toe of wall shall be provided at least 1m away from wall.

6.3 External Drainage System

- Designer should assess the potential stormwater and design surface drainage system upto final disposal of storm water.

7. Reinforcements

7.1 Different types of reinforcements used in reinforced soil walls are: -

1. **Non-Extensible:** Metallic elements like bars, strips, plates etc.
2. **Extensible:** Polymeric elements like strips, grids, rods, mesh etc.

7.2 All types of Reinforcements are taken beyond the Rankine zone into the resistant zone to ensure sufficient bond and anchorage.

7.3 Steel reinforcement used in RS wall systems shall conform to Clause 27.1 of IS 18591 given in **Annexure-II**.

7.4 Polymeric reinforcement (Geogrids and Geo-strap) used in RS wall systems shall conform to Clause 27.2 IS 18591 as given in **Annexure-II**.

7.5 Quality Assurance (number of tests and type of tests) for geosynthetic products shall conform to Clause 10 of IS 17373 and Clause 9 of IS 17372 given in **Annexure-II**.

7.6 Manufacturer of soil reinforcing elements and associated RS wall accessories shall be ISO 9001:2015 certified. Manufacturer shall have a NABL/GAI-LAP accredited in-house laboratory with computer-controlled testing machines for all QC tests of relevant supplied RS wall components.

7.7 Field pullout testing of geosynthetic reinforcement shall be carried out to validate the soil-reinforcement interaction coefficient adopted in design, using the proposed geosynthetic, backfill, and actual field compaction methodology. (Pullout Test during construction should be performed as per **Annexure-III**).

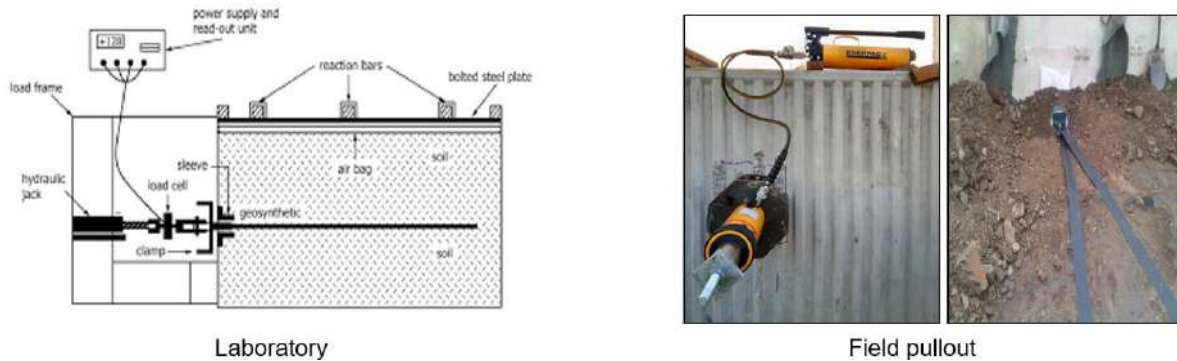


Figure 4: Pullout Test

8. Facia Panel

8.1 The facing is provided to prevent spilling/falling over of the fill and also to provide firm anchorage to the reinforcement. Facings should be tough and robust. Facing also provides an aesthetic architectural finish to the RS structure.

1. Precast reinforced concrete panels
2. Precast concrete blocks and precast concrete hollow blocks
3. Gabion Facing

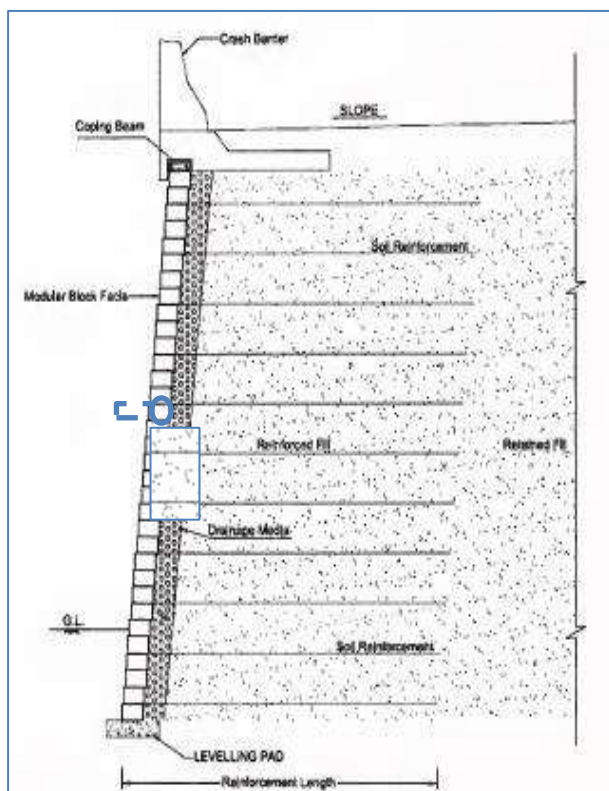


Figure 5: Typical Cross Section of RS Wall with Modular Block Facia

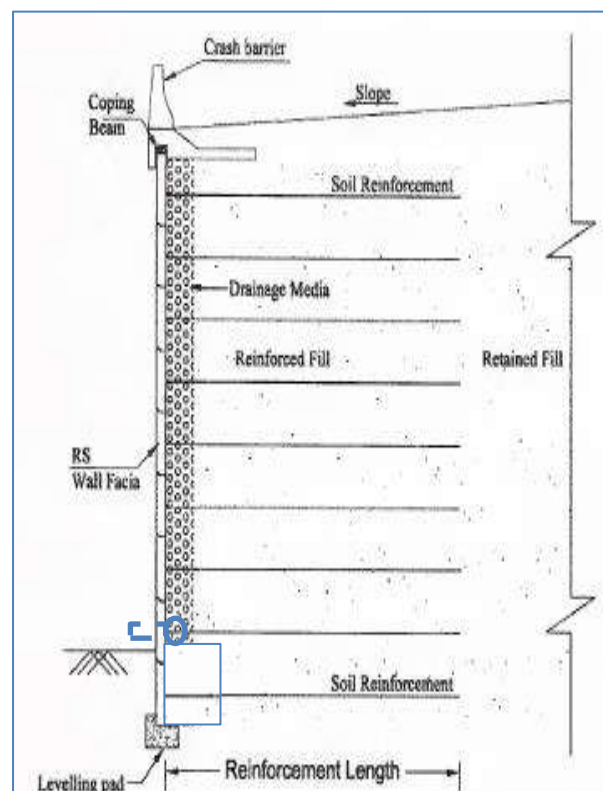


Figure 6: Typical Cross Section of RS Wall with Concrete Panel Facia

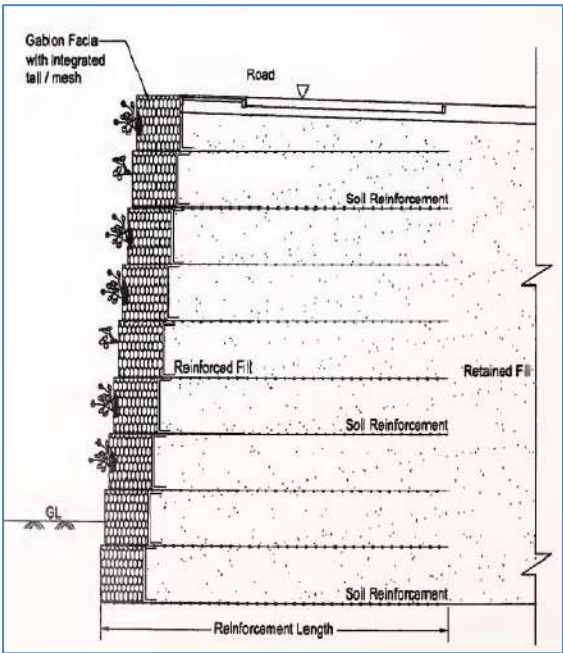


Figure 7: Typical Cross Section of RS Wall with Gabion Facia with Integrated Tail



Figure 8: Modular Blocks with Architectural Finish



Figure 9: Panels with Architectural Finish

8.2 Minimum thickness of Facia panel should be 160 mm excluding architectural finish.

8.3 Modular Block should be manufactured by block making machine with minimum M35 Grade concrete. Hollow area should not exceed 40% of cross-sectional area. Outer side of block shall be 85 (mm) thick and inner side shall be 45 (mm) thick. The minimum thickness of the block shall be 300 mm to achieve connection strength through friction.

8.4 Facia Panel Tolerances are given in the table below

Sl. No.	Characteristics	Tolerance
1	For precast RCC panels:	
1a	All dimensions within (i.e., a and b shown in figure below)	± 5 mm
1b	Evenness of front face (like, m shown in figure below)	± 5 mm over 1500 mm
1c	Differences between length of two diagonals (i.e., between x and y shown in figure below)	5 mm (maximum)
1d	Thickness (i.e., c shown in figure below)	+5 mm
2	For modular blocks:	
2a	Length and Width (i.e., L and B shown in figure below)	± 2.5 mm
2b	Dimension for height (i.e., H shown in figure below)	± 1.5 mm

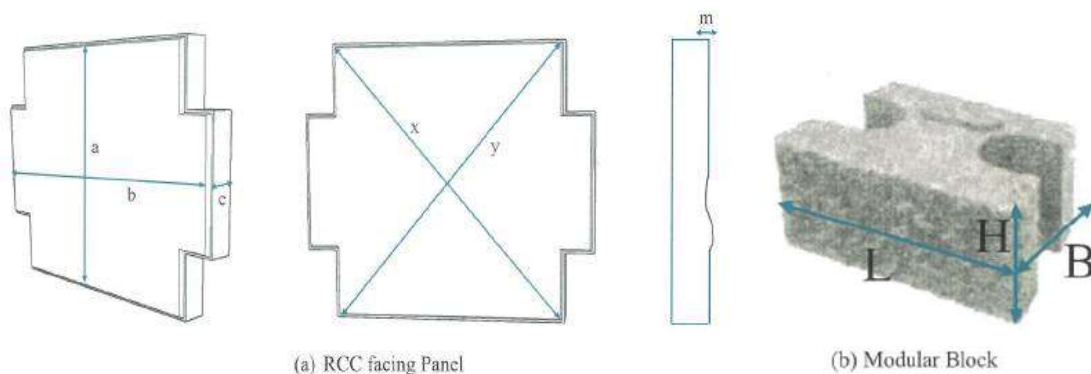


Figure 10: Representation of tolerances for (a) RCC facing panel, and (b) modular block

8.5 Connection System

- Different type of reinforcements and Connections used in RS walls are shown in **Annexure-IV**.
- The connection between the facia panels and the reinforcing element can be constructed using various techniques like nut and bolt, HDPE inserts with bodkin joint, hollow embedded devices, polymeric/ steel strips/ rods/ pipes, fiberglass dowels, frictional or any other method after being duly designed and tested.
- In case of modular block facing where the reinforcement is held by friction between the facia block and the reinforcement, the results of pullout test as per ASTM D 6638 shall satisfy the requirement of the Long-Term Design Strength of the primary reinforcement.
- Project-specific connection tests are mandatory.
 1. Blocks-geogrid connection strength test is mandatory and shall be performed as per ASTM D6638 and IRC SP 102 Sec. 3.4.
 2. Panels-geogrid/geostrips connection strength test is mandatory. The connection Strength test as shown in **Annexure-V**.
- The connection strength values obtained from above tests shall be used in design check of connections as per Clause 34.12.15 of IS 18591.
- All exposed steel components including steel connection system, loops, bars etc. shall be galvanized to minimum 500 gsm.

9. Traffic Barrier

9.1 Traffic barriers (Crash barriers) are constructed over the front face of the reinforced walls. Commonly, a friction slab is used to transfer the lateral loads due to impact of vehicles on the Barriers.

9.2 Typically a friction slab varies from 1500 to 2500 mm width and 250 mm thick depending on the type of crash barrier provided.

9.3 The impact traffic load on barriers constructed over the front face of walls must be designed to resist the overturning moment by their own mass.

9.4 The wall design should ensure that the reinforcement does not rupture or pull-out during the impact event.

9.5 The impact force resulting due to the impact shall be distributed equally to the upper two rows of the soil reinforcement, which the reinforcements resist over their full length.

9.6 The upper layer of soil reinforcement shall be designed for a rupture impact load equivalent to a static load of 33.5 kN/m of wall and the second layer be designed with a rupture impact load equivalent to a static load of 8.8 kN/m.

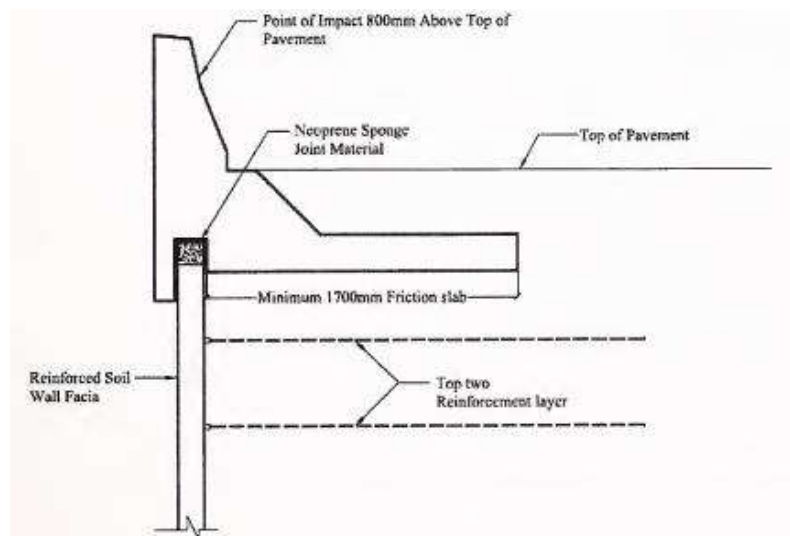


Figure 11: Crash Barrier Section without shoulder

10. Other Material Specifications

- 1 **Non-woven geotextile** to be used as separation/filtration shall conform to Section 3 of IS 18591.



Figure 12: Non-woven Geotextile

2 Bearing Pad:

1. Walls using segmental precast concrete panels require bearing pads in their horizontal joints (and diagonal, if applicable) that provide some compressibility and movement between panels during elastic compression and settlement of the reinforced fill and avoid concrete-to-concrete contact. These materials are generally ethylene propylene diene monomer (EPDM) rubber pads or HDPE.
2. Two bearing pads are usually used on 1.5 m wide panels and at least three bearing pads with 3 m wide panels. A minimum of three bearing pads are used per horizontal panel joint.

3. The stiffness (axial and lateral), size, and number of bearing pads should be sized such that the final joint opening shall be at least $15 \text{ mm} \pm 5 \text{ mm}$ unless otherwise shown on the plans.



Figure 13: EPDM bearing pads

4. Requirements of Bearing Pads is given in the **Annexure-VI**.

11. Ground Improvement Techniques

11.1 Construction of RS wall over soft subsoil causes difficulties in both design and construction because of the low shear strength and high compressibility of such soils. Embankments on soft soil may fail due to:

1. Failure of soft subsoil in shear (failure in bearing capacity)
2. Sliding of embankment fill and underlying soft subsoil (failure along a slip circle)
3. Excessive settlements and also lateral displacements

11.2 Ground conditions which require ground improvement include:

1. Uncontrolled/unsuitable fills like loosely dumped soils, debris, waste materials;
2. Organic soils;
3. Weak and compressible fine-grained soils;
4. Expansive soils;
5. Loose coarse-grained soils; and
6. Strata with cavities

11.3 Various Ground Improvement Techniques to be used are:

1. Full replacement of soft subsoil covering entire width of embankments with soil of better load bearing characteristics
2. Use of Geocell Mattress or Geogrids (Basal Reinforcement)
3. Use of Stone Columns to improve the bearing capacity of soft subsoil
4. Use of Prefabricated Vertical Drains (PVD) with preloading
5. Combination of the above

6. Any other appropriate deep treatment method based on soil strata type and loading conditions.

11.4 Geocell Mattress (Basal Reinforcement)

The methodology provides "stiff raft" by providing 3D confinement to granular material.

- Clear the site and level the ground. Lay a non-woven geotextile separator over the soft subgrade to prevent the "pumping" of fines into the geocell layer.
- Expand the geocell panels to their full dimensions. Use J-pins or rebar stakes to anchor the corners and maintain the honeycomb shape.
- Join adjacent panels using heavy-duty staples or specialized plastic keys to ensure the mattress acts as a continuous unit.
- Fill the cells with granular material (crushed stone, gravel, or sand). To avoid damaging the cells, minimum 150 mm granular material shall be placed above geocell.
- Compact the infill using a light vibratory roller (<8 T). The first pass should be done without vibration to lock the material, followed by standard compaction.



Figure 14: Geocell Basal Reinforcement (Prefabricated/Factory made Geocells)



Figure 15: Geogrid Basal Reinforcement

The construction procedure for a site-fabricated geocell system (Figure 16) made from rigid geogrids is summarized below:

- Clear and level the ground. Place a geotextile separator if required. Lay the base rigid geogrid flat with minimum 300 mm overlap between adjacent sheets.
- Place uniaxial rigid geogrids perpendicular to the embankment centerline. Tie one edge to the base geogrid using nylon ties or braid at regular spacing.
- Fix temporary posts at both ends and insert rods through end apertures. Raise diaphragms to vertical position and apply manual tension. Provide intermediate posts for longer lengths if needed.
- Mark spacing along diaphragm tops and stagger alternate rows. Install diagonal grids between transverse members to form triangular/diamond cells. Connect using HDPE or compatible nodal connectors.
- Using the approved granular material, fill the first two rows of cells to half height. Then fill the first row to full height. Continue filling, ensuring that the leading row is always half filled before the trailing row is fully filled. Filling may be carried out by mechanical plant operating directly on top of filled cells. Provide minimum 150 mm compacted cover before trafficking and remove tensioning posts after filling.

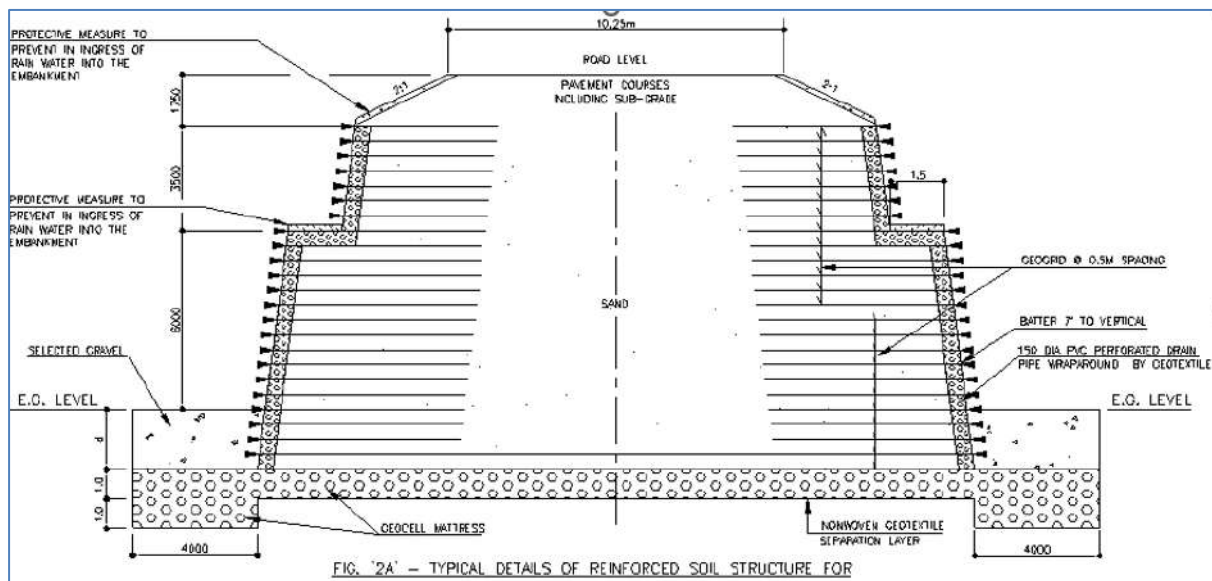


Figure 16: Geocell Mattress (Geocell made by rigid geogrids)

11.5. Stone Columns (Vibro-Replacement)

- This method involves creating vertical columns of compacted stone to reinforce the soil and provide drainage.
- Approximate diameter of the stone column in the field may be determined from the known compacted volume of material required to fill the hole of known length and maximum and minimum densities of the stone.
- Stone columns should be installed preferably in an equilateral triangular pattern which gives the densest packing although a square pattern may also be used.

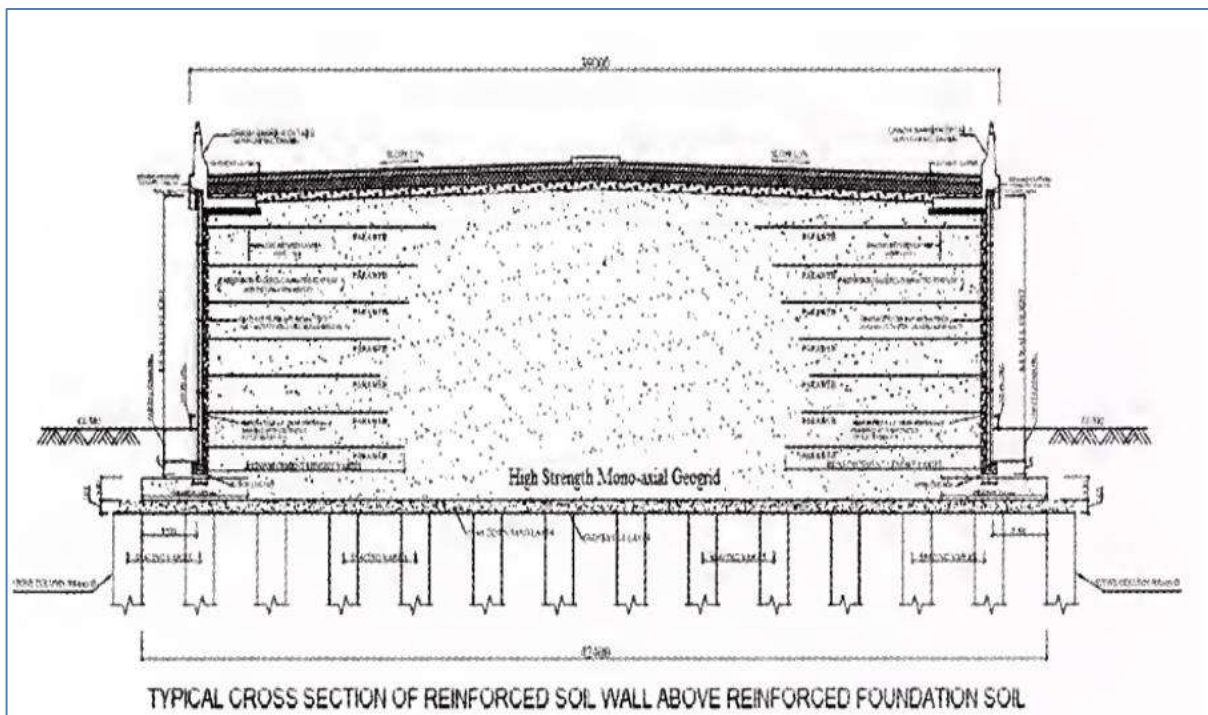


Figure 17: Stone Columns

11.6. Prefabricated Vertical Drains (PVD)

The methodology focuses on "stitching" the ground to allow pore water to escape under pressure.

- A sand blanket (0.5m to 1.0m thick) is laid over the entire area first. This acts as the horizontal drainage path for the water that the PVDs will bring to the surface.
- A specialized PVD rig with a tall mast and a hollow steel "mandrel" is used.
- The PVD material (the wick) is threaded through the mandrel and attached to a small steel anchor plate at the bottom.

- The mandrel is pushed or vibrated into the ground to the required depth (often 10m to 30m).
- Once at depth, the mandrel is withdrawn. The anchor plate keeps the PVD in place at the bottom.
- The PVD is cut about 15–20cm above the sand blanket to ensure the water discharges into the drainage layer.

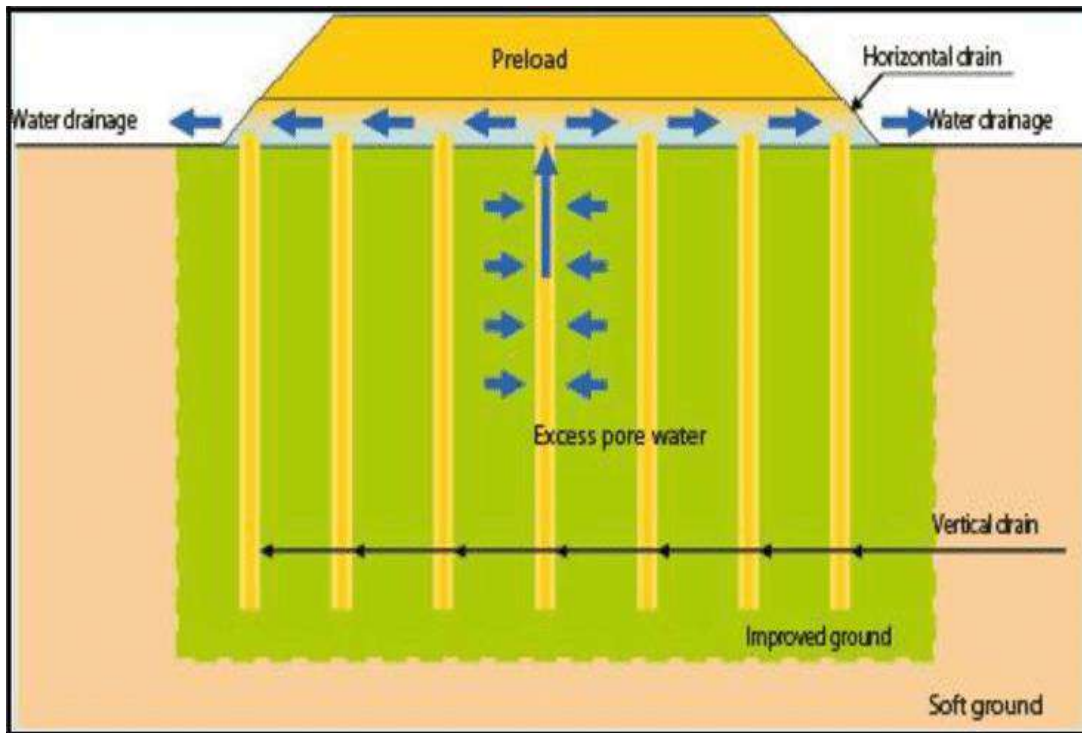


Figure 18: Prefabricated Vertical Drains (PVD)

12 Design and Detailing

12.1 Load and Resistance Factor Design (LRFD) method shall be used for design of RS walls. Strength (Resistance) shall be scaled down by a factor and applied load shall be scaled up as per section 4 of IS 18591.

12.2 The basic design parameters, steps and analysis for RS wall shall be as per Clause 34.5 of IS 18591.

12.3 Minimum length of reinforcement shall be greater than $0.7 \times$ Design Height (Sum of embedment depth and exposed height of wall up to top of facing unit) or 3.0 m.

12.4 Vertical spacing of primary reinforcement shall not be greater than 800 mm for panel and 600 mm or twice the block depth whichever is minimum for block panel.

12.5 Gap slab type structure shall be avoided in all respect, by providing wall type abutment. Typical section shown in **Annexure-IX**.

12.6 In case of Gap slab is unavoidable, the maximum length of gap slab should be restricted to 2m. Gap slab arrangement is provided as per **Annexure-IX**.

12.7 The reinforced soil wall shall be designed for different limit states in each failure mode that is, external, internal, compound, and global. The limit states to be checked in each mode are as follows:

12.8 Check for external stability:

1. Check for Sliding
2. Check for Bearing Capacity
3. Check for Global Stability

12.9 Check for Internal Stability:

1. Check for Internal Sliding
2. Check for Rupture of Reinforcement
3. Check for Adherence / Pull-out of Reinforcement

12.10 Long-Term Design Strength (LTDS) of Geosynthetic Reinforcement

- Manufacturer shall provide soil-reinforcement reduction factors certified by an accredited third-party or based on accredited laboratory (NABL/GAI-LAP) tests as per relevant BIS codes and produce certification like BBA, NTEPE and HKCED as per IRC 113.
- A Declaration of Conformity (DoC) shall be provided stating that supplied product is identical to tested product (creep, installation damage, durability).
 - The designer should check to make sure that the manufacturer data are representative of the products likely to be received at the project site (that is, the product test data should be current, and the product manufacturing process, polymer source etc., should not have changed since the testing was conducted). In all cases, the geosynthetic product line must be re-evaluated on a periodic basis to assess any changes that may affect the product and corresponding reduction values.
- Long term design strength, approval of product and creep testing requirements shall be as per IS 18591 and IRC SP 102 given in **Annexure-VII**.

13. Construction Protocols

13.1 Foundation and Leveling Pad

- Excavate foundation as per approved drawings. If site conditions contradict geotechnical reports, verify foundation soil through additional investigation. If founding soil is high compressibility and low shear strength (< 50 KPa), ground improvement is to be carried out as per **Clause no. 11**.
- Minimum Depth of foundation shall be 1.0 m below ground level in case rock is met above founding level, the depth of embedment shall be adjusted as per ground conditions.
- Levelling pad of 150 mm thick (minimum). M15 plain cement concrete having 1.0 m width for block and minimum 350 mm width for panels to be placed below the first row of fascia layer.

13.2 Facing and Reinforcement Placement

- Use a chalk line on the leveling pad to guide the first course of panels/blocks. Correct alignment which is critical as it dictates the positioning of all subsequent courses.
- Set facing unit at an additional batter than as provided in the drawings since there is a tendency for initially positioned units of facia to lean outward as the fill material is placed and compacted. Care and caution shall be taken to accommodate this phenomenon. At the end of the construction, the face may have a slight residual inward batter.
- Lay reinforcements (geogrids/geostrips) on an even surface, perpendicular to the wall face and the length shall be as shown in drawing.
- Ensure flexible reinforcement is pulled taut to remove all slack before covering it with fill.
- Cover polymeric reinforcements with fill within 24 hours of placement to prevent UV degradation.
- Place minimum three EPDM/HDPE bearing pads at every horizontal panel joint as specified in the drawings to prevent concrete-to-concrete contact and allow for minor movement.
- Cover all vertical and horizontal joints on the backside of the facing with geotextile filters to prevent backfill "bleeding".

13.3 Backfilling and Compaction Strategy

- The reinforcing elements shall be laid free from all kinks, damage and displacement during placing, spreading, leveling and compaction of the fill. The programme of filling shall be such that no construction plant moves directly on the reinforcement. Fill material shall conform to **Clause no. 5**.
- A drainage bay of minimum 600 mm width at the back of the facing shall be provided as an adequate drainage measure.
- All construction equipment having a mass exceeding 1.5 Tonnes shall be kept at least 1.5 m away from the face of slope or wall. In the area up to 1.5 m from the face of slope or wall, the following compaction equipment shall be used:
 - Vibratory roller having a weight per metre width not exceeding 1300 kg with total weight not exceeding 1500 kg
 - Vibratory plate compactor of maximum weight 1000 kg
 - Vibro tamper having a weight not exceeding 75 kg
- Before allowing the movement of vehicles over the reinforcement, a minimum compacted thickness of 150 mm shall be provided over the reinforcement and the speed of the vehicles shall be restricted to 10 km/hr.
- For design of coping beam, crash barrier and friction slab shall be provided as per the design and drawings.

13.4 Summary of Compaction Protocols to be followed:

Description	Compaction within 1.5 m of fascia	Compaction away from 1.5 m of fascia
Recommended compaction equipment	Plate compactors or baby roller less than 1,500 kg weight	Vibratory roller (steel, smooth-drum vibratory roller equipped with a variable amplitude system, a speed control device, and a vibration frequency system with no less than 1,000 vibrations per minute) Use of Intelligent compactors shall be encouraged.
Maximum compacted lift thickness	200 mm	200 mm
Water	Before spreading water shall be added to achieve water content in range of +/-2% OMC	Before spreading water shall be added to achieve water content in range of +/-2% OMC
Number of passes	As per field compaction trial (Annexure-VIII)	As per field compaction trial (Annexure-VIII)
Relative Compaction Requirement	95% MDD of modified proctor laboratory test (For subgrade 97%)	95% MDD of modified proctor laboratory test (For subgrade 97%)

***Field compaction trial procedure shall be followed as per Annexure-VIII**

13.5 Field Quality Assurance of Fill Material during construction shall be as per frequency given below:

Test Method	Frequency
Field Density Sand Replacement Method	1 set per 3000 m ² (1 set = 10 tests) of compacted area, or closer
Field Density If, Nuclear Gauge Method	Double Frequency (i.e., 20 tests per 3000 m ²)
Gradation and Atterberg limits	1 set per 3000 m ² (1 set = 10 tests)
Direct Shear Test	1 set per 6000 m ² (1 set = 10 tests)

Test Method	Frequency
(at 95% MDD, OMC saturated sample Consolidated Drained test)	

Note:

- Ensure, atleast One (01) point of testing within 1.5 m of facing.
- Ensure, atleast One (01) point at middle of reinforced zone and 1 point at end of reinforced zone.
- For nuclear gauge method, site specific correlation shall be obtained at site calibration before using full-scale for density checks.
- The design friction angle, fill material gradation and PI should satisfy design and specification requirements.
- Filed density shall be greater than or equal to 95% MDD of modified proctor laboratory test for fill soil. Acceptance criteria shall be as per MORTH Clause 903.2.2.
- For gradation analysis, wet sieving and hydrometer analysis is compulsory for ensuring fines is less than 15% for reinforced fill.
- AE/IE shall appoint a dedicated civil engineer (geotechnical engineer preferable) only to ensure fill QA (borrow are testing, field densities, testing of fill during construction), record them appropriately and maintain required compliances. 100% QC/QA tests of reinforced fill should be checked by AE/IE.
- Site laboratory is compulsory and testing shall be done at site laboratory and personnel involved in testing shall be trained mandatory before start of project.

13.6 Best practices & Do's/Don'ts may be used for ready references.

Feature	Do's ✓	Don'ts ✗
Compaction	Use vibratory rollers for the main reinforced soil mass and lightweight roller / plate compactor within 1.5 m of the facing.	Do not use heavy compaction equipment within 1.5 m of the facing units, as it can cause panel tilting and excessive outward movement.
Reinforcement	Ensure geogrid is properly aligned, tensioned, and securely connected to the facing units as per approved design details.	Do not permit construction vehicles or equipment to operate directly on exposed geogrid without a minimum 150 mm protective soil cover.
Drainage	Provide a continuous drainage layer (graded aggregate) behind the facing up to the heel, along with longitudinal slotted drain pipe.	Do not obstruct or omit drainage layers or outlets, as buildup of pore water pressure is a primary cause of RS wall distress and failure.

Feature	Do's ✓	Don'ts ✗
Fill Moisture Control	Maintain backfill moisture content within $\pm 2\%$ of OMC during placement and compaction.	Do not compact fill that is excessively wet or dry, as it leads to poor compaction.
Backfill Material	Use/Select backfill satisfying: $\phi > 30^\circ$ Fines ($< 75 \mu\text{m}$) $< 15\%$ $PI < 6$	Do not use clayey, highly plastic, or poorly graded soils within the reinforced zone, as they increase settlement and drainage problems.
Geosynthetic Storage	Store geosynthetic rolls off the ground, protected from UV exposure, rain, and damage.	Do not drag geosynthetic rolls on the ground or leave them exposed to sunlight/weather for more than 24 hours.
Facing Batter	Provide an initial inward batter to account for outward movement during compaction and service life.	Do not construct facing units plumb initially, as outward deformation is inevitable during compaction.
Fill Uniformity	Use uniform backfill material throughout a continuous wall stretch to ensure consistent performance.	Do not change fill type within the same wall stretch, as it leads to differential settlement and uneven deformation.
Panel Placement	Remove temporary wooden wedges/shims only after completion of one panel level atleast and sufficient confinement.	Do leave wedges till completion of total height of wall construction.
Surface Water Control	Provide proper diversion drains to prevent water from entering the RS wall construction area.	Do not allow surface runoff or stormwater to flow into the reinforced soil zone during or after construction.



Figure 19: Typical pre-cast panel lifting and placement using RS wall system vendor supplied panel lifting equipment and appropriate construction machinery

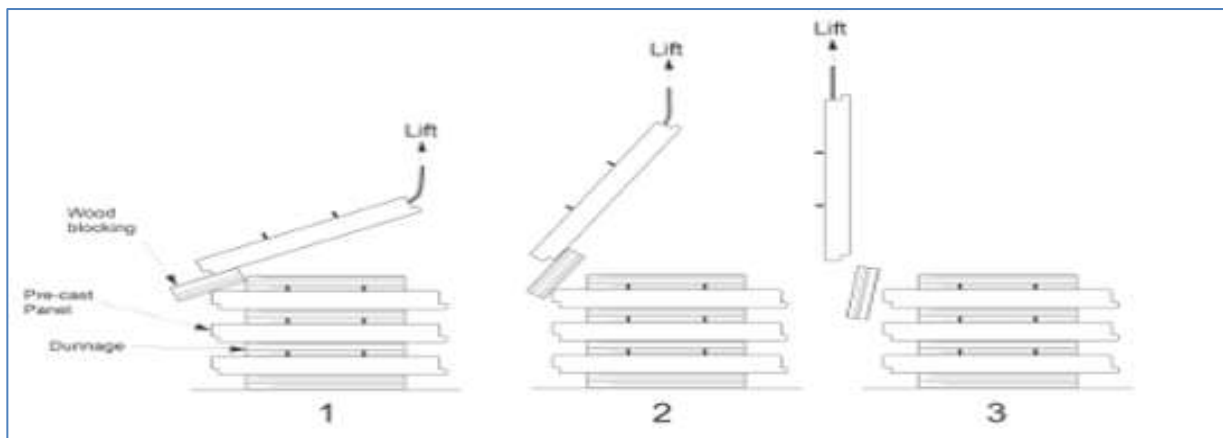


Figure 20: Recommended procedure for lifting pre-cast panels from stacks to minimize damage



Figure 21: Typical initial course pre-cast panel placement operation

14. Quality Assurance from System Provider

14.1 The system provider shall ensure following:

- To produce performance certificate as a documentary proof that the proposed system to be used (type of reinforcement, facing) for the given application i.e. RS wall, conforming to BIS Standards has been successfully used in India or elsewhere in Highways.
- Mandatorily provide One (01) Qualified and trained Engineer (BE Civil) and One (01) Qualified and Trained supervisor (Diploma Civil) at site, for every 20,000 sqm of reinforced soil fascia. The minimum relevant experience of the aforesaid manpower shall be 05 (five) Years.

- Detailed design shall be done based on RS wall system components, materials and systems including connection system proposed by specialized technology provider, which shall be proof checked from reputed institutions like IIT/NIT/CRRI/capable independent geotechnical consultants.
- Contractor/Concessionaire shall ensure signing of agreement between the Contractor/Concessionaire and Technology Provider before use of RS wall and Geosynthetic material in NH Project in compliance with Para 4.7 MoRT&H Policy Circular EFile No.RW/NH-34049/01/2020-S&R (P&B)pt. (Computer No.-207229) dated 20th September 2024. The agreement shall have the provision of involvement of the Technology Provider during execution from start to end of the RS wall construction. Technology provider shall be responsible for all aspects of RS wall construction including accuracy of geotechnical investigations, design, supervision and ensuring quality of construction including fill material. Technology Provider shall deploy the requisite design experts/material technologist/skilled & trained construction supervision personnel to certify material testing & material characterization for design, proof check of the design, approve construction methodology including field trial sections before actual construction, quality control and supervision & certification of the day-to-day construction/execution. A copy of such agreement shall be furnished to AE/IE and to RO of the Ministry / NHAI/NHIDCL for reference and record. The agreement format is given in **Annexure-X**.
- The warranty for proprietary products shall be submitted by technology provider along with all other documents as required by IRC SP: 112-2017 “Manual for Quality Control in Road and Bridge works”. Minimum warranty period of the proprietary products shall be 30 years.

ANNEXURE-I

SOP for Partial Height RE walls

1. Partial height:

i) **Design: Provision for Future Widening of Reinforced soil wall**

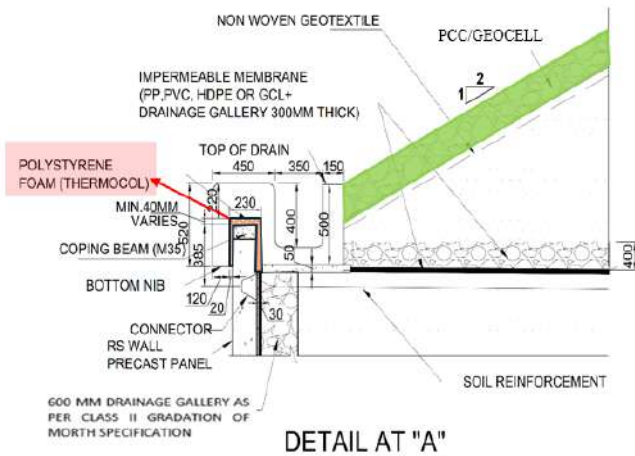
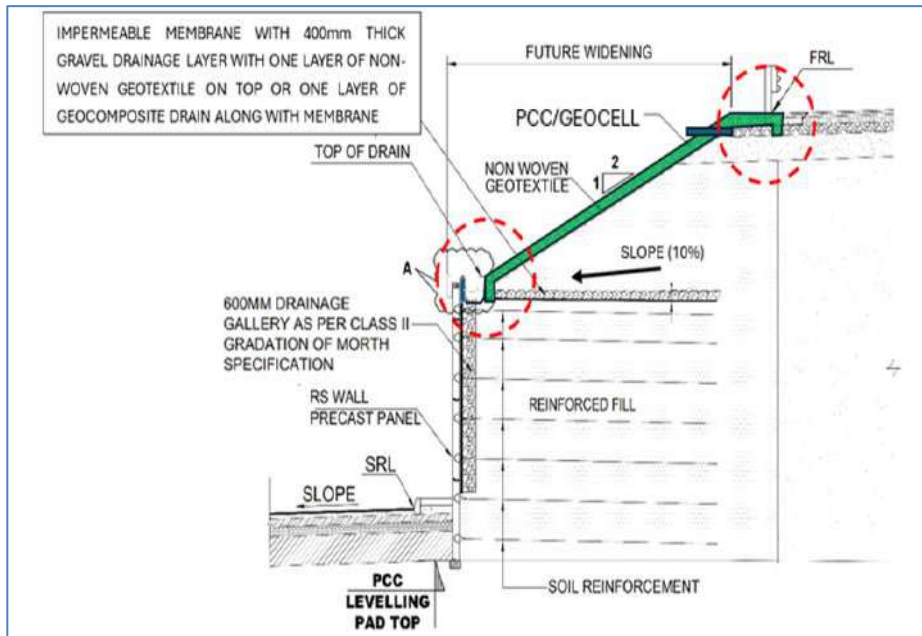
To ensure long-term stability of the reinforced soil wall under both current and future conditions, the design must account for additional loads anticipated from future road widening, including:

- Active earth pressure from retained soil.
- Surcharge loads due to the widened roadway section.

Following design steps to be considered

1. Step-1-Wall shall be designed as partial height wall
2. Step-2-Wall to be designed as full height wall.

The design shall consider both reinforcement length and strength for the Reinforced soil wall, ensuring that the wall dimensions and reinforcement detailing are adequate for the worst-case loading scenario, which includes future road widening and associated surcharge loads. This approach guarantees structural integrity without requiring future modifications.



Prefer Saucer Drains

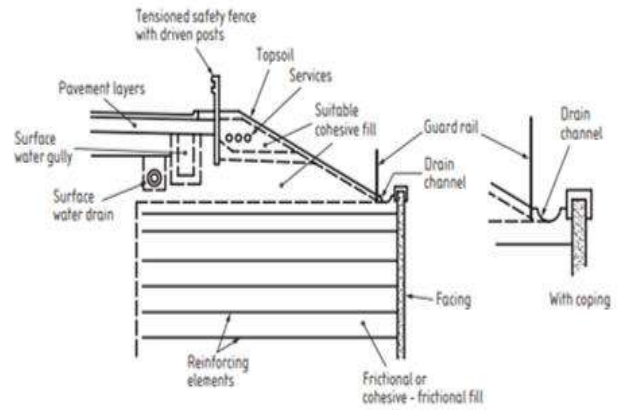


Figure 1: Partial Height wall detailing (Considering future widening)

27.1 Steel Reinforcement

27.1.1 Hot Dip Galvanised Steel Strips

27.1.1.1 The steel strips shall be galvanized hot rolled steel strip with transverse ridges to have high pullout capacity type high adherence (HA) or thicker at connection point type high adherence reinforced (HAR) strips.

27.1.1.2 The steel strips shall have minimum tensile strength of 490 MPa complying with the requirements of IS 2062 with minimum elongation (on base metal) of 18 percent or the steel strips shall have minimum tensile strength of 550 MPa and yield strength of 450 MPa complying with minimum guaranteed elongation (on base metal) of 17 percent. The steel strip shall have minimum tensile, bearing and shear strength of 490 MPa, complying with the requirement of IS 2062. [Fig. 2](#) shows typical steel strip reinforcement used in reinforced soil walls and [Fig. 3](#) shows the typical connection details.

27.1.1.3 The steel strips shall be positively connected using nuts and bolt with the facing panels by using lugs, which are placed during pre-casting. The panel lugs are manufactured from hot-rolled steel strip. The steel strip used for lugs should have minimum tensile of 490 MPa, complying with the

requirement of IS 2062, except the elongation (on base metal) shall be minimum 22. After fabrication, the HA and HAR strips and panel lugs are hot dip galvanized requirements as per IS 4759, except that the average zinc coating weight is not less than 520 g/m² (75 micron).

27.1.1.4 Reinforcing strips shall be cut to the lengths and tolerances shown on approved drawings. Holes for bolts shall be punched in the locations shown.

They shall be carefully inspected to ensure they are true to size and free from defects that may impair their strength or durability. The chemical requirement of the steel listed below as soil reinforcement shall be as given in [Table 7](#).

Nominal dimensions and the design strength of the strips and panel lugs for 100 years of design life are given in [Table 8](#).

Table 7 Chemical Requirement of the Steel Reinforcement

(Clause 27.1.1.4)

Sl No.	Characteristics	Requirement, Percent Max
(1)	(2)	(3)
i)	Carbon: C	0.24
ii)	Manganese: Mn	1.6
iii)	Phosphorus: P	0.045
iv)	Sulphur: S	0.045
v)	Silicon: Si	0.55

IS 17373 : 2020

Table 1 Requirements of Uniaxial Polyester Geogrids (Type 1, Knitted or Woven)
(Clause 6.2)

SI No.	Characteristic	Requirement											Method of Test, Ref to
		60/20	80/30	100/30	120/30	150/30	180/30	200/30	250/30	300/30	350/30	400/30	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	Ultimate tensile strength, <i>kN/m, Min</i>												IS 16635
	a) MD	≥60	≥80	≥100	≥120	≥150	≥180	≥200	≥250	≥300	≥350	≥400	
	b) CD	≥20	≥30	≥30	≥30	≥30	≥30	≥30	≥30	≥30	≥30	≥30	
ii)	Elongation at designated load, <i>percent</i>												IS 16635
	a) MD	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	
	b) CD	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	
iii)	UV resistance, strength retained after 500 h exposure, <i>percent</i>	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 13162 (Part 2)
iv)	Chemical resistance, strength retained after 72 h immersion, <i>percent</i>	≥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.

Table 3 Requirements of Uniaxial Polyester Geogrids (Type 3, Bonded)
(Clause 6.2)

SI 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 (<i>kN/m, Min</i>)																			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	1	
ii)	Elongation at designated load in MD and CD, <i>percent</i>	≤12	≤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, <i>percent</i>	≥70	≥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, <i>percent</i>	≥70	≥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.

10 SAMPLING AND CRITERIA FOR CONFORMITY

10.1 Lot

All geogrid rolls of same material, construction and type dispatched to a buyer against one dispatch note shall constitute a lot.

10.2 Unless otherwise agreed to between the buyer and the seller, the number of geogrid rolls to be selected at random from a lot shall be as given in column 3 of Table 4.

Table 4 Scale of Sampling

(Clause 10.2)

SI No.	No. of Rolls in Lot	Sample Size	Sub-Sample Size	Permissible No. of Defective Rolls
(1)	(2)	(3)	(4)	(5)
i)	Up to 50	3	2	0
ii)	51 - 150	5	2	0
iii)	151 - 300	8	3	1
iv)	301 - 500	13	5	2
v)	501 and above	20	5	3

10.3 Number of Test Specimens and Criteria for Conformity

Number of test specimens and criteria for conformity shall be as given in Table 5.

Table 5 Number of Test Specimens and Criteria for Conformity

(Clause 10.3)

SI No.	Characteristic	No. of Rolls	Criteria for Conformity
(1)	(2)	(3)	(4)
i)	Clause 5.1, Tensile, elongation, length and width	According to column 3 of Table 4	The defective rolls/pieces do not exceed the corresponding number given in column 5 of Table 4
ii)	All other requirements	According to column 4 of Table 4	All the test specimens shall pass the tests

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Table 1 Requirements of Geostrips (GS)
(Clause 5.2)

SI No.	Characteristic	Requirement									Method of Test, Ref to
		GS-20	GS-30	GS-37.5	GS-40	GS-50	GS-60	GS-75	GS-85	GS-100	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	Ultimate tensile strength (kN), <i>Min</i>	20	30	37.5	40	50	60	75	85	100	IS 16635
ii)	UV resistance (500h), strength retained, <i>percent</i>	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 13162 (Part 2)
iii)	Chemical resistance, strength retained after 72 h immersion, <i>percent</i>	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	≥70	IS 17363
iv)	Width, mm	←————— 50 to 95 (Tolerance ± 3mm) —————→									—
v)	Roll length, m	←————— 50 to 150 (Tolerance +1 m with no negative tolerance) —————→									—

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.

9 SAMPLING AND CRITERIA FOR CONFORMITY

9.1 Lot

All geostrip rolls of same material, construction and type dispatched to a buyer against one dispatch note shall constitute a lot.

9.2 Unless otherwise agreed to between the buyer and the seller, the number of geostrip rolls to be selected

at random from a lot shall be as given in column 3 of Table 2.

Table 2 Scale of Sampling
(Clause 9.2)

SI No.	No. of Rolls in Lot	Sample Size	Sub-Sample Size	Permissible No. of Defective Rolls
(1)	(2)	(3)	(4)	(5)
i)	Up to 50	3	2	0
ii)	51 - 150	5	2	0
iii)	151 - 300	8	3	1
iv)	301 - 500	13	5	2

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Table 10 Requirements of Woven Geotextile Made from Virgin Polymer of Polypropylene for Walls and Slopes
(Clauses 27.2.2 and 42.4)

SI No.	Characteristics	Requirement	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Ultimate tensile strength (machine direction: MD), kN/m	≥ 60	IS 16635
ii)	Ultimate tensile strength (cross direction: CD), kN/m	≥ 20	IS 16635
iii)	Elongation at ultimate strength in MD and CD, percent	≤ 35	IS 16635
iv)	Chemical resistance, strength retained after 72 h immersion, percent	≥ 70	IS 17363

NOTE — The design strength of reinforcement should be calculated as per the method given in Section 4.

Table 9 Requirements of Woven Geotextile Made from Virgin Polymer of Polyester for Walls and Slopes

(Clause 27.2.2)

SI No.	Characteristics	Requirements	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Ultimate tensile strength (machine direction: MD), kN/m	≥ 60	IS 16635
ii)	Ultimate tensile strength (cross direction: CD), kN/m	≥ 20	IS 16635
iii)	Elongation at ultimate strength (MD&CD), percent	≤ 15	IS 16635
iv)	Chemical resistance, strength retained after 72 h immersion, percent	≥ 70	IS 17363

NOTES

1 Molecular weight of the polyester polymer shall be greater than 25 000 g/mol.
 2 Carboxyl end groups < 30 mmol/kg.
 3 The design strength of reinforcement shall be calculated as per method given in Section 4.

Table 11 Requirements of Woven Geotextile Made from Virgin Polymer of Polyester — Basal Reinforcement

(Clauses 27.2.2 and 42.4)

SI No.	Characteristics	Requirement	Test Method, Ref to
(1)	(2)	(3)	(4)
i)	Ultimate tensile strength (machine direction: MD)	≥ 100 kN/m	IS 16635
ii)	Ultimate tensile strength (cross direction: CD)	≥ 20 kN/m	IS 16635
iii)	Elongation at ultimate strength (MD&CD)	≤ 15 %	IS 16635
iv)	Chemical resistance, strength retained after 72 h immersion	≥ 70 %	IS 17363

NOTES

1 Molecular weight should be greater than 25 000 g/mol.
 2 Carboxyl end groups < 30 mmol/kg.
 3 The design strength of reinforcement should be calculated as per Section 8.
 4 The minimum strain requirements shall be satisfied as per Section 8 for a given application.

Table 13 Requirements of Drainage Composite*(Clause 28.2)*

Sl No.	Characteristics	Requirement	Tolerance	Method of Test, Ref to
(1)	(2)	(3)	(4)	(5)
i)	Thickness at 2kPa, mm, <i>Min</i>	6	–	IS 13162 (Part 3)
ii)	Mass per unit area, g/m ² , <i>Min</i>	1 040	–	IS 14716
iii)	Tensile strength MD/CMD, kN/m	20/20	- 10 Percent	IS 16635
iv)	CBR puncture resistance, N, <i>Min</i>	3 000		IS 16078
v)	Resistance to weathering	To be covered with soil for 14 days		IS 13162 (Part 2)
vi)	Resistance to chemicals	Excellent		IS 17363

NOTE — Manufacturer has to provide test report for the factors, such as compression creep, chemical and biological clogging and geotextile intrusion, to derive long term flow.

Table 14 In-Plane Flow Requirements of Drainage Composite*(Clause 28.2)*

Sl No.	Confining Pressure, kPa	Unit of Measurement	In-plane Water Flow MD (R/S) Hydraulic Gradient - 1.0		In-plane Water Flow MD (S/S) Hydraulic Gradient - 0.1		Method of Test, Ref to
			Requirement (4)	Tolerance (5)	Requirement (6)	Tolerance (7)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(6)
i)	20	litre/m.s	2.4	- 0.40	0.67	- 0.13	IS 17179
ii)	100	litre/m.s	1.95	- 0.33	0.53	- 0.11	IS 17179
iii)	200	litre/m.s	1.45	- 0.24	0.37	- 0.07	IS 17179

NOTES

1 S/S with soft/soft foam contact surfaces to simulate textile intrusion into the core due to soil pressure from both sides.

2 R/S rigid/soft contact surfaces to simulate conditions where composite is placed against rigid concrete surface on one side and soil on other side.

3 Placement of drainage composite shall be carried out at site by keeping machine direction in vertical direction.

Methodology for Conducting Field Pull Out Test on Geostrip for Reinforced Soil Wall

A. Apparatus and Material Required for Field Pull Out Test.

1. Precast concrete panels.

Precast concrete panels having same dimension as panel to be used for the project need to be cast for this test with provision of central hole of dia. 160mm located at the centre of panel.

2. Hydraulic jack with pressure gauge.

Hydraulic jack with hollow plunger is to be used for the loading/pulling of Geostrip. The calibrated pressure gauge needs to be attached to measure the load/force.



Photo No 1: Hydraulic jack with pressure gauge.

3. Soil Reinforcement strips

Geostrip reinforcement strips should be free from any damage/ cuts. Width and length of Geostrip shall be in conformity with design and drawing.

4. Loop & toggle arrangement

To facilitate the pulling, Geostrip shall be connected to Loop & toggle or equivalent suitable arrangement (for destructive testing) with hydraulic jack as shown in photo. Loop & toggle arrangement consists of two steel loops of minimum 12mm dia. & toggle bars of minimum 30mm dia. This assembly is connected to jack with high tension bolt/ ropes on one side & connected with Geostrip on other side.

B. Soil Tests for Pull Out Test

Backfill or reinforced soil test shall be tested for ascertaining its properties. These properties are directly linked with the test results, hence same shall be derived before start of test.

Following are the tests to be conducted on backfill soil

- Modified Proctor test for OMC & MDD
- Direct shear tests for shear strength parameters.

C. Site Preparation

- Precast panel should be cast and proper curing to be done for minimum 15 days. The hole position should be at the centre of panel as shown in the drawing. The diameter of hole should be minimum 160mm.



Photo No 2: Panel with 160mm diameter Hole.

- The position of panel should be pre-planned and it should be at such a location where assembly of jack and stand can be done. Preferably the location should be about 1m above the ground level.
- Place the precast panels at the required location.
- Backfilling shall be done in layers of 200mm compacted thickness. Compaction shall be carried out as per the standard procedure laid down in construction manual. FDD test should be done for each layer and compared with MDD report.
- Stop the backfilling process once it reached up to centre of hole.
- Place the foam in the hole so that soil should not come out from hole.
- Lay the Geostrip reinforcement in 'V' shape (as shown in drawing/photo) & pass it on toggle bar in such a way that other end of the loop & toggle shall be protruding till the

centre of the hole. Anchor the rear end of the Geostrip reinforcement by J-hooks & anchor bar.



Photo No 3: Geostrip Installed for test.

- Measure the length & width of the Geostrip reinforcement strips which will be embedded in soil.
- Place and compact backfill over the Geostrip reinforcement strips as per the standard procedure laid down in construction manual.
- After 1st layer of backfill placement, remove “J” hook and rear anchor installed for tightening of Geostrip. Continue the backfilling process after removal rear anchor.
- Particular care should be taken around central hole that soil should not enter slip in the hole. Hand compaction need to be done nearby the hole.
- Continue with placement and compaction of the backfill to a height not exceeding 800mm above the reinforcement.

D. Methodology for Field Pull Out Test

Once the filling is done up to top of panel with proper compaction of soil & placing of reinforcement, set up is ready for testing. Geostrip shall be installed at minimum 3 locations for pull out testing.

Following steps need to be followed for the pull-out test.

- After proper placement of fill & Geostrip, the foam which is fixed inside the hole shall be removed, exposing the end of loop & toggle bar.

- Stand for holding the jack on the panel should be fixed with anchor fastener arrangement.
- The position of stand should be aligned properly so that centre of hole and jack are aligned.
- Connect the high tensile bar/ rope to the loop and toggle assembly to exert pulling force.
- Place the jack on the stand. Secure the jack with stand to maintain its position for application of load.
- Pass the high tensile bar/rope through central hoe of jack. Jack and Pump with pressure gauge should be connected to each other.
- Assembly should be checked for its proper working. Measure the height of backfill on the Geostrip.



Photo No 4: Positioning of Jack and stand on hole



Photo No 5: Measurement of Backfill thickness above Geostrip.

- Fix the rear end of high tensile rod/rope with plunger/ moving ramp of jack.
- Once the jack and loop & toggle are placed in position, an appropriate calibrated displacement measuring gauge must be attached to monitor the displacement of the Geostrip.

- The initial seating load (when pressure gauge records at least one division) shall be applied to overcome slack in the connections and assembly. This load on the pressure gauge must be recorded before commencing actual loading.
- The specimen must be loaded at a constant rate of 200 Psi. Load and displacement should be recorded at every 200 Psi interval.

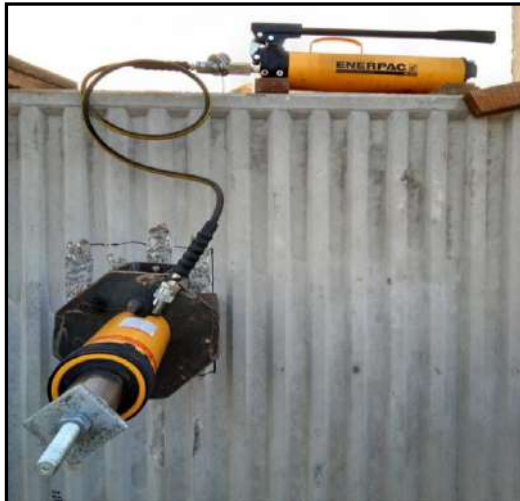


Photo No 6: Jack and Pump Assembly



Photo No 7: Measurement of Displacement

- When further application of load does not result in an increase in load cell dial gauge reading, it can be interpreted that pullout has occurred. Pull out testing may be continued upto a displacement of 75 mm.
- The final load and displacement readings must then be recorded.

E. SUMMARY

The objective of pull-out test is to determine the pull-out resistance of the soil Geostrip reinforcement. Failure in the above test may be due to pull out of reinforcement from soil.

F. CALCULATIONS

TEST DATA

- Reinforcement grade –
- Reinforcement length –
- Reinforcement width --
- Density of backfill soil -
- Height of backfill soil above reinforcement. -

Sl. No.	Pull out Force Applied Pa	Displacement	Interface Factor Ci

G EQUATIONS

- Interface Factor $C_i = \frac{Pa}{2(b*Le)*\gamma*h*\tan\Phi_p}$

Where,

1. Pa = Max. pull out force recorded
2. b = width of the reinforcement
3. Le = Embedded length of reinforcement
4. γ = Unitweight of backfill soil
5. Φ_p = Angle of friction for backfill soil

H Conclusion -

The interface factor C_i calculated from test data should be greater than C_i taken in design against same over burden.

Different type of reinforcements and Connections used in RS walls

S. No.	Type of Reinforcements in RS wall	Image
1.	Schematic of panel and geogrid reinforced soil wall system (c type connection)	
2.	Schematic of panel and geogrid reinforced soil wall system (loop and toggle connection)	
3.	Schematic of panel and geostrip reinforced soil wall system (cavity connection)	
4.	Schematic of panel and geostrip reinforced soil wall system (loop and toggle connection)	

<p>5.</p>	<p>Schematic of block and geogrid reinforced soil wall system</p>	
<p>6.</p>	<p>Schematic of gabion and geogrid reinforced soil wall system</p>	
<p>7.</p>	<p>Schematic of panel facing and steel strip reinforced soil wall system</p>	

Procedure for Connection Test

Precast RCC Panel Connection Strength Testing for Reinforced Soil Structures

1. Scope

This document defines the methodology, setup, execution, and acceptance criteria for carrying out in-situ ultimate connection strength testing of precast RCC facing panels and soil reinforcement connection used in reinforced soil structures such as reinforced soil walls, abutments, and other retaining structures.

The procedure is applicable under simulated field conditions, to determine the ultimate tensile connection strength in accordance with IS 18591:2024.

2. Reference Standards

- **IS 18591:2024** – *Reinforced Soil Structures – Code of Practice*
 - **Clause 34.12.15** Check for Connection Strength

3. Introduction

Connection strength is a critical design parameter in reinforced soil structures, governing the load transfer mechanism between the soil reinforcement elements and the facing panels. The design connection strength is established based on:

- Analytical calculations, and
- Experimental testing results obtained under simulated field conditions.

As per IS 18591 (Clause on Connection Strength Testing), the ultimate connection strength shall be determined through testing that closely replicates actual site conditions.

This test method describes the ultimate connection strength test, including the test setup, loading system, boundary conditions, and measurement protocol, to accurately estimate the connection pull-out capacity under tensile loading.

4. Definition of Connection Strength Test

A connection strength test is an in-situ / laboratory tensile test conducted to measure the maximum force that the connection–panel interface can sustain before failure, under tensile loading induced by soil reinforcement elements.

The test captures:

- Connection pull-out or rupture,
- Panel cracking or local failure,
- Interaction and group effects when multiple connectors act together.

5. Test Setup

5.1 Panel and Connector Arrangement

- A full row of connectors attached to a precast RCC facing panel shall be tested simultaneously.
- The preparation of panels for test set is explained below:



Figure 2 Panel reinforcement and connector placement witness



Figure 3 Concrete pouring into steel moulds



Figure 4&4: preparing concrete cube samples for testing and checking concrete slump



Figure 5: Compacting concrete using vibrator



Figure 6: Panel Ready for testing.



Figure 7: Panel Ready for testing, placed inside the test pit.

- Reinforcement elements (straps, strips, bars, or geosynthetic connectors) shall be connected as per actual construction detailing.
- The panel shall be placed in a test pit or platform allowing free deformation.

5.2 Loading System

- Tensile load shall be applied using:
 - Hydraulic jack(s),
 - Reaction frame or deadman system,
 - Calibrated load cell.
- Load application shall be **axial and concentric** to the reinforcement elements.

5.3 Simulation of Backfill Condition

- With sand or granular medium shall be placed between the steel loading plate and the panel face, as shown in Figure 8a & 8b.
- This layer enables:
 - Realistic panel deformation,
 - Stress redistribution,
 - Interaction between adjacent connectors.



Figure 8a and b – Connection Strength Testing Setup

6. Testing Methodology

6.1 Correct Method of Testing (Recommended)

(Refer Figure 9 – Schematic Connection Strength: All Connectors Tested Simultaneously)

- Load is applied to all connectors in a panel row at the same time.
- The sand cushion between the panel face and loading plate allows:
 - Development of a free failure envelope,
 - Accurate simulation of site stress conditions.
- Group effect and stress overlap among connectors are realistically captured.

This method complies with the intent of IS 18591 Clause on testing under representative field conditions.

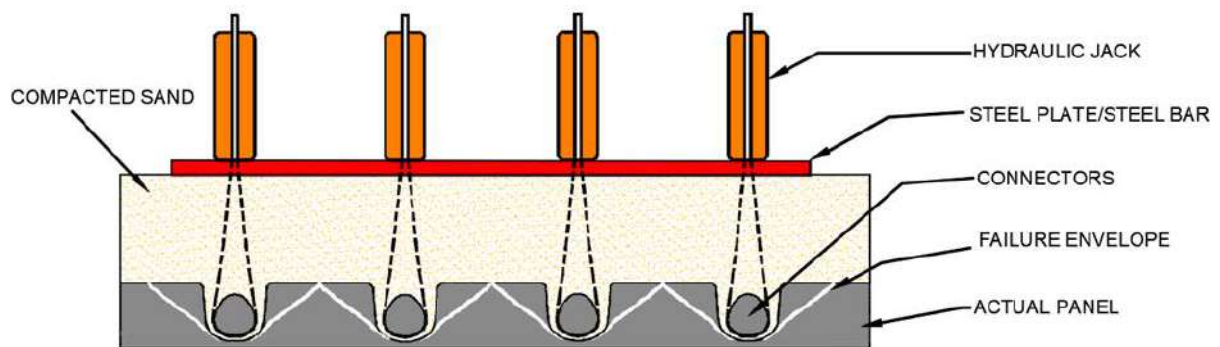


Figure 9– Schematic Connection Strength: All the Connectors Tested Simultaneously

7. Loading Procedure

1. Apply a seating load (approximately 5–10% of expected ultimate load).
2. Increase load in controlled increments (e.g., 10–15% of design load).
3. Maintain each load increment for a specified duration (e.g., 1–2 minutes).
4. Continue loading until:

- Ultimate failure occurs, or
- Significant deformation or connector rupture is observed.

8. Observations and Measurements

- Applied load (kN)
- Load–displacement behaviour
- Mode of failure:
 - Connector rupture,
 - Pull-out,
 - Panel cracking,
 - Local crushing or yielding
- Deformation pattern of panel and connectors

9. Determination of Ultimate Connection Strength

- The ultimate connection strength shall be taken as:
 - The maximum load sustained prior to failure, or
 - Load corresponding to excessive deformation, as defined in IS 18591.
- Design connection strength shall be derived by achieving appropriate factor of safety, as specified in IS 18591 clause 34.12.15.

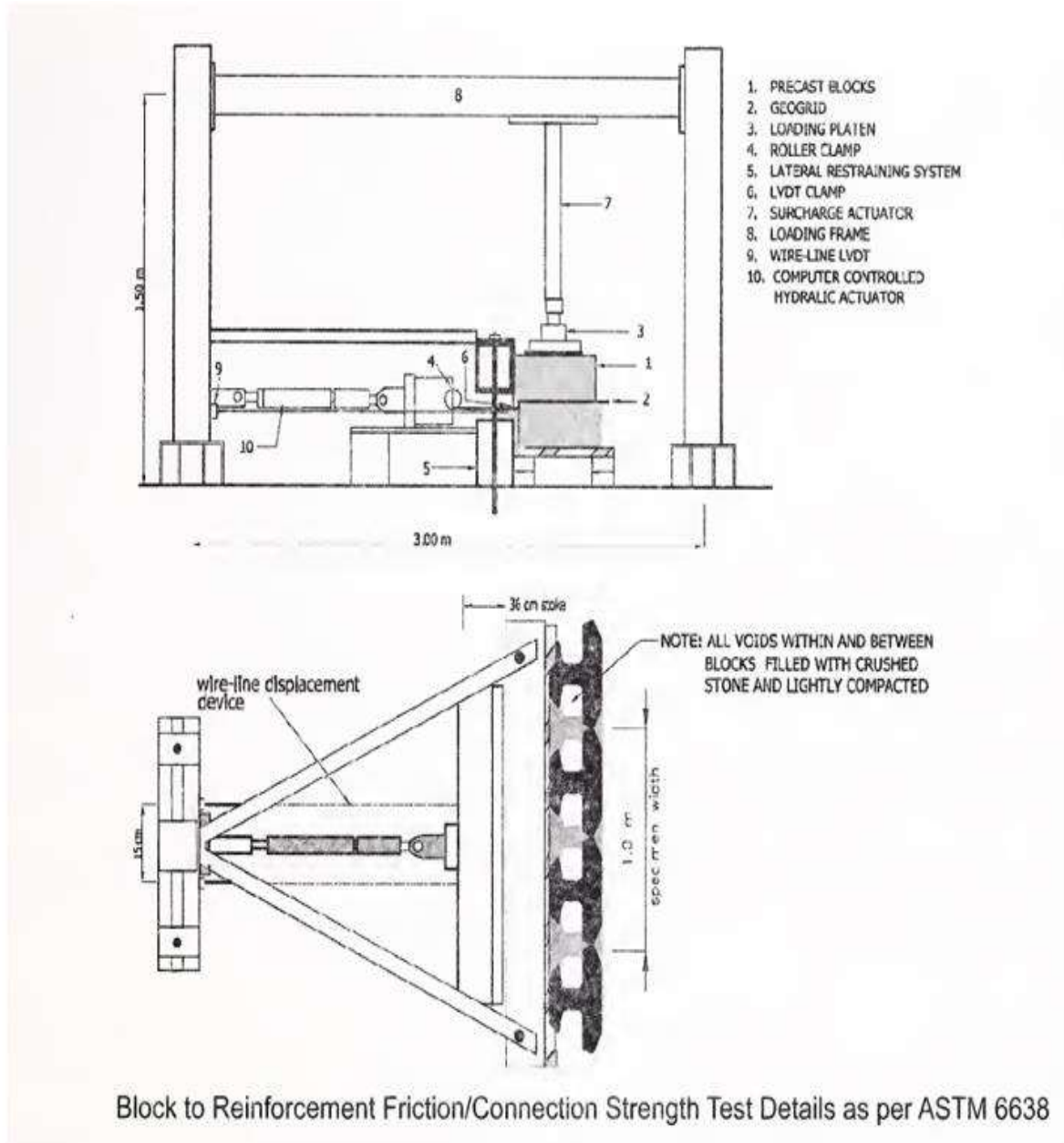
10. Reporting

The test report shall include:

- Description of panel and connector type
- Test setup photographs and schematic diagrams
- Load–displacement curves
- Failure observations
- Ultimate connection strength value
- Compliance statement with IS 18591

11. Conclusion

Accurate assessment of connection strength requires testing on actual panels under simulated site conditions with a free failure envelope. The procedure described herein ensures compliance with IS 18591 and provides reliable input for the safe and economical design of reinforced soil structures.



Requirements of Bearing Pads

Sl. No.	Characteristics	Requirement	Method of Test
1.	Base polymer	EPDM	—
2.	Colour	Black	Visual
3.	Grade, type and class	Grade 2, Type A, Class A	ISO 4097
4.	Hardness (Sh.A)	80±5	IS 13360 (P5/S11)
5.	Tensile strength (MPa), Min	12	IS 3400 (Part 1)
6.	Elongation at break, %, Min	200	IS 3400 (Part 1)
7.	Heat ageing (70 °C for 70 h)		
	Change in hardness (points), Max	±15	IS 3400 (Part 4)
	Change in tensile, %, Max	±30	IS 3400 (Part 4)
	Change in elongation, %, Max	-50	—
8.	Compression set (70 °C for 22 h), %, Max	50	IS 3400 (P10/S1&2)
9.	Resistance to ozone (quality retention), %, Min	85	IS 3400 (Part 20)
10.	Water resistance (70 h @ 100 °C), vol change %, Max	10	IS 3400 (Part 6)
11.	Max ash content, %	8±2	IS 11720 (Part 5)

ANNEXURE-VII

Requirements for LTDS and Creep Parameters of soil reinforcing element

The specialized technology provider shall have in-house design, supervision and audit team. The manufacturer of soil reinforcing element shall be ISO 9001:2015 certified by an internationally accredited organization and shall have inhouse computer controlled tensile testing facilities for ensuring quality of soil reinforcement and independent third-party certification as per IRC 113-2013 Annexure.

Sourcing of design, material, supervision, etc. for reinforced soil wall structure from multiple agencies shall be strictly prohibited. The specialized agency, appointed by the main contractor, must be either a manufacturer of soil reinforcing elements of reinforced soil walls or source the material from a manufacturer conforming to the following;

The manufacturer shall provide soil reinforcement reduction factors certified by an independent third-party agency as per clause 3.7 of IRC 113-2013

Consideration of Damage Factors as per IS 18591:2024 and IRC SP 102 Clause 3.5:

- The damage factor for soil reinforcement shall be evaluated based on the connection system adopted.
- If a granular drainage layer is used, the damage factor at the connection point shall

Reduction Factor	Requirement
Creep Reduction Factor	Polymeric reinforcement shall have minimum of 10000 hours creep test data and SIM test data at different temperatures to evaluate partial material factor for creep as per ISO TS 20432. Creep factor should be declared at design temperatures of 20°, 30° & 40°.
Installation damage factor	Installation damage factor depends on the type of coating of reinforcement and size of aggregates used at site.
Durability	Durability reduction factors based on proposed backfill' s pH value, design temperature at site location & service life are also required.

be considered for the same material.

PQ Criteria for Technology Provider

The specialized technology provider shall have in-house design, supervision and audit team. The manufacturer of soil reinforcing element shall be ISO 9001:2015 certified by an internationally accredited organization and shall have NABL or GAI-LAP accredited inhouse laboratory with computer-controlled testing machines to ensure quality of all RS wall system components. The manufacturer of RS wall accessories shall be ISO 9001:2015 certified by an internationally accredited organization and shall have NABL accredited inhouse laboratory. The in-house laboratory shall be accredited for the tests for which reports are furnished by them, Independent third-party certification/test reports from accredited testing laboratories/ institutions as per IRC 113-2013 can be accepted in case of special tests that cannot be conducted at the manufacturing unit. However, the manufacturer shall have in-house test facility to conduct Quality Control (QC) testing for the RS wall system component(s) manufactured by them. For example, a drainage composite manufacturer shall have permeability and in-plane flow testing equipment and be accredited by NABL or GAI-LAP to perform these tests to monitor and perform QC testing.

- Manufacturer shall provide soil reinforcement reduction factors certified by an independent third-party agency or tested from the accredited laboratories/ institutions as per clause 3.7 of IRC 113-2013.
- The manufacturer shall declare their soil reinforcement reduction factors as per IRC SP 102
- The specialized technology provider shall produce performance certificate as a documentary proof that the proposed system to be used (type of reinforcement, facing) for the given application i.e. either MSE Wall or RS Slope (whichever is applicable), has been successfully used in India or elsewhere in Highways.

FIELD COMPACTION TRIAL

Field Compaction Trial (also referred to as Backfill Banking Test) shall be conducted prior to commencement of backfilling works in order to establish the Banking Rule and Basis for achieving the specified degree of compaction based on Lab tests (Heavy compaction test, IS:2720 (Part-8)).

The trial shall be conducted using the same soil, construction equipment, layer thickness, moisture control method, and compaction machinery proposed to be adopted in the permanent works.

The increasing trend of density with increase in number of passes of a compactor tends to diminish gradually and a 'diminishing return stage' is reached. This will determine the type of compactor including its frequency, corresponding water contents and number of roller passes.

The approved outcome of the Field Compaction Trial shall form the basis for routine field compaction control during execution.

If fill material or procedure or equipment or roller or roller frequency is planned to be changed during execution, field compaction trial shall be conducted for each new set. Before field compaction trial, fill material shall be tested to meet the specifications to be used in RE wall. If reinforced fill and retained fill are different, separate banking tests shall be conducted for both.

Methodology for conducting field compaction trial:

1. Construct a test ramp about 20 m long, 6 m wide & 0.6 m thick (**Figure 1**), preferably at the construction site, over a level ground surface clear of bushes, depressions etc under nearly identical conditions.
2. Start compaction trial by placing fill at chosen moisture content within range of OMC $\pm 2\%$.
3. Fix the observation points as shown in Figure 1.

4. Collect samples around the observation points (Figure 1). Determine moisture content by any suitable standard method. Also measure levels using total station.
5. Compare the moisture content with that of the relevant desired moisture content (Step 2).
6. Wait for natural drying if moisture content is on higher side or sprinkle appropriate amount of water uniformly followed by ploughing etc. and leave for 5 to 30 minutes depending on type of soil, in case the moisture content is on lower side (Step 2).
7. Determine final moisture content once again at sampling points before rolling.
8. Roll the entire width and measure the dry density (by any standard method) of the soil around observation points after each pass. Also measure levels at observation points after each roll passage using total station. Measurement of dry density and moisture content shall be taken after removing top 5 cm layer of earth with least possible disturbance.
9. Carry out similar procedure for compaction Layer-2 and compaction Layer-3.
10. Levels during compaction process at observation points may be obtained to record settlement from uncompacted state to compacted state with number of passes.
11. From these test results, plot dry density v/s number of roller passes for each cross section and for each layer.
12. Plot all the compaction layers data in same plot and obtain average density plot.
13. From these field values, minimum no. of passes of particular roller shall be decided.
14. AE/IE shall witness all field and lab tests during field compaction trial and approve the same.
15. For RE wall fill compaction, the engineer/supervisor shall ensure thus obtained minimum number of passes of roller during compaction of each layer at all locations.

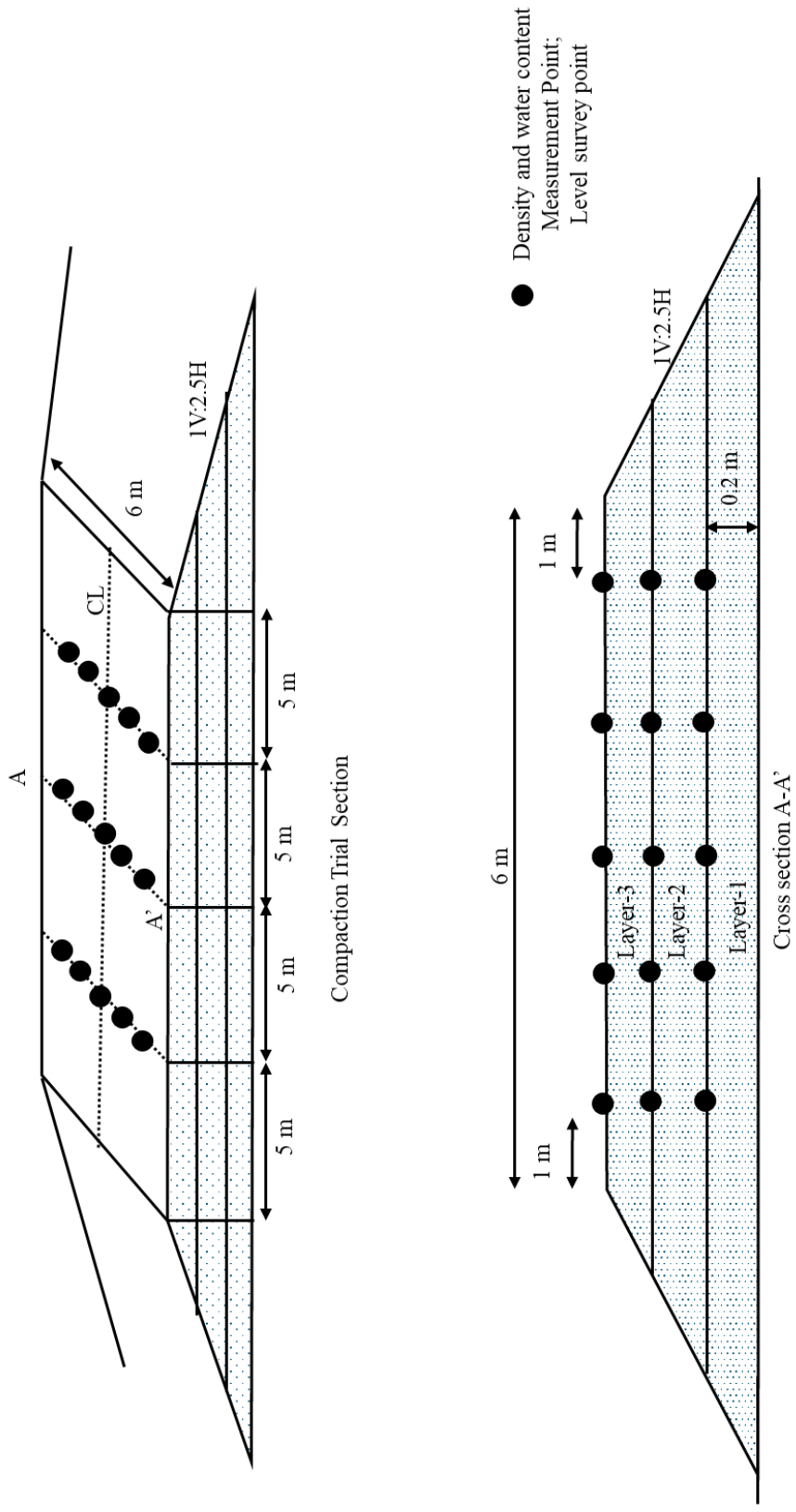


Figure 1 Schematic of Field Compaction Trial Plan

Practices for Gap Slab, Approach Slab, and Friction Slab Arrangement for Reinforced Soil (RS) Wall Approaches

1. Gap Slab:

- Construction practices for gap slabs, closing / back RS walls with column type abutments shall be provided. Only earth retaining abutments with dirt wall i/c bracket to support the approach slab shall be avoided.
- Provision of RS walls as wing walls of grade separated structures or any other structures shall be avoided. Only RCC wing walls shall be avoided.
- In case of Gap slab is unavoidable as in running project, the maximum length of gap slab should be restricted to 2m as given in point no. 3.

2. Type A: Approach Slab without Gap Slab

Applicability

- Where the horizontal gap between RS wall fascia panels and wall type abutment

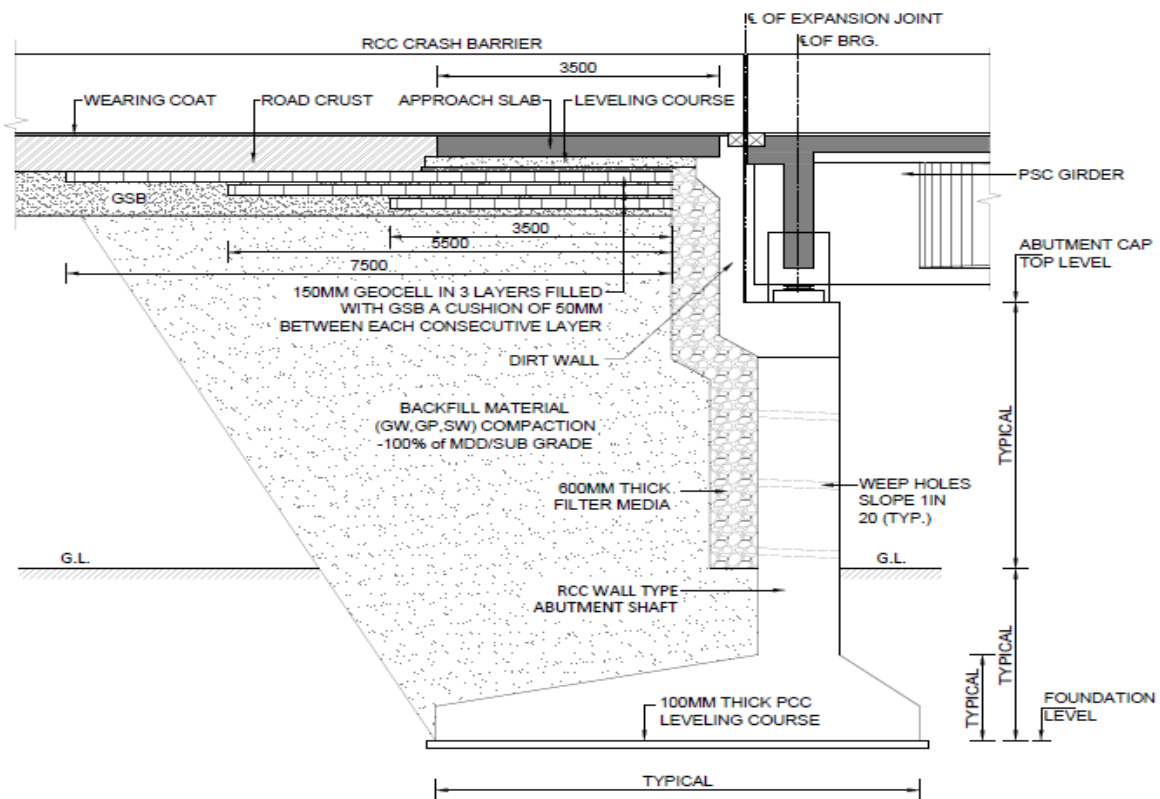


Figure 5 RS wall at approach slab location for wall type abutment

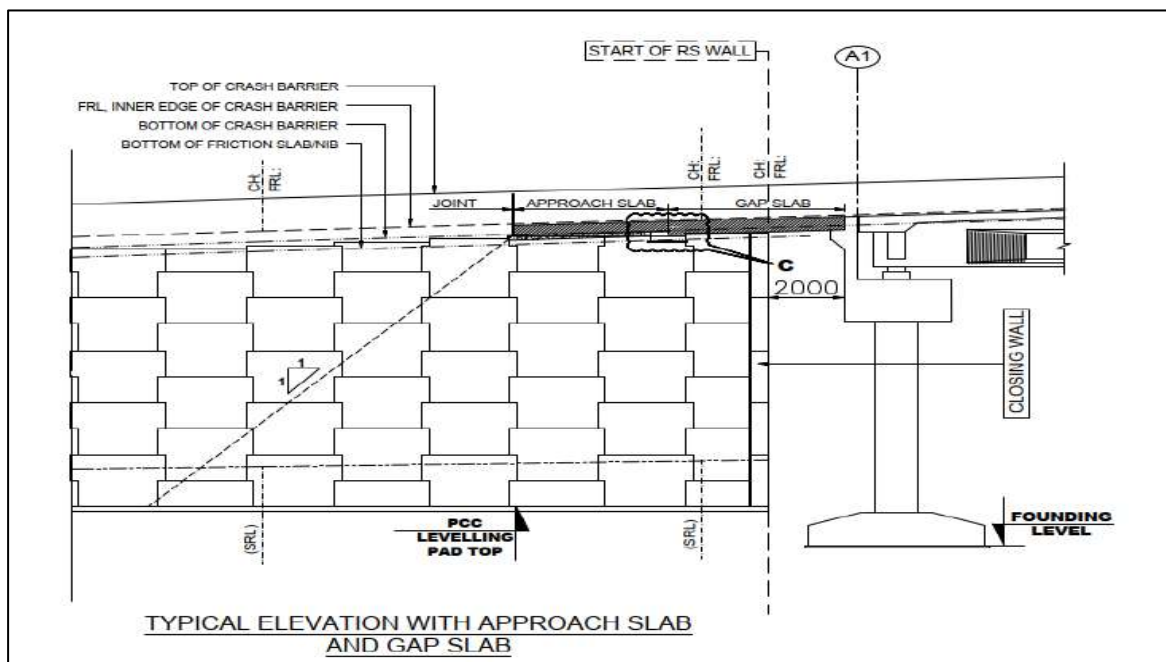
Recommended Arrangement and design considerations

- No separate gap slab shall be provided.
- Approach slab shall rest on:
 - 150 mm Geocell in 3 layers filled with GSB as shown in Figure 1.

3. Type B: Gap Slab up to 2.0 m Length

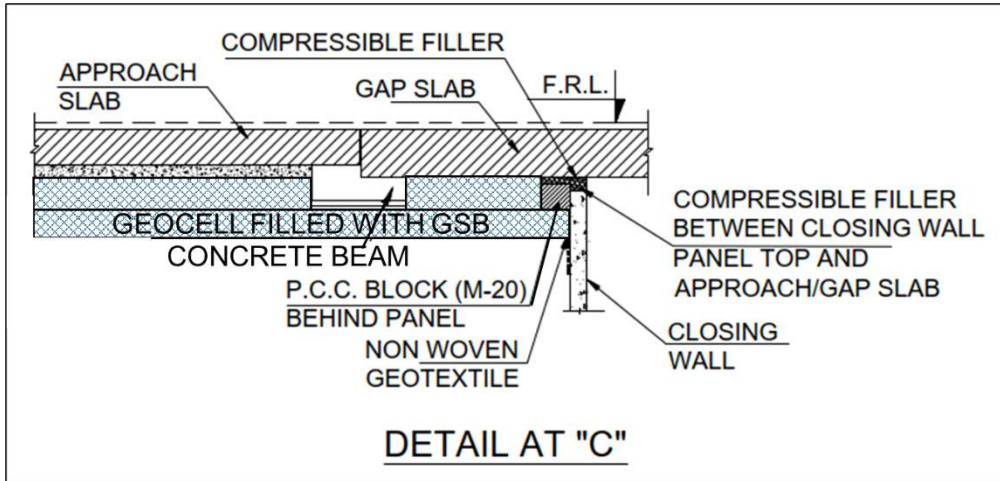
Applicability

- Where the gap between RS wall fascia panels and abutment is less than or equal to



2.0 m.

- *Figure 2:RS wall with Gab slab arrangement*



Recommended Arrangement & design consideration.

- A gap slab shall be provided.
- On the RS wall side, the slab shall rest on:
 - **150 mm Geocell in 2 layers filled with GSB** as shown in Figure 2.

Closing wall should be designed.

AGREEMENT BETWEEN CONCESSIONAIRE/CONTRACTOR AND TECHNOLOGY PROVIDER

Project: "Name of Work"

Reference: 1. Work Order & Amendments.

Definition:

First Party: hereinafter referred to as the Concessionaire/Contractor
,
registered office at

Second Party: hereinafter referred to as the
Technology Provider

All the above are collectively referred to hereinafter as 'Parties and individually as "Party" in this Agreement.

Purpose:

Fulfil and comply to the requirements specified in Para 4.7 Policy Circular EFile No.RW/NH-34049/01/2020-S&R (P&B) pt. (Computer No.-207229) dated 20th September 2024 issued by the Ministry of Road Transport & Highways, Government of India

Whereas,(Client) had awarded the work of..... (hereinafter called as Project) vide Contract No dated. . for the.....and subsequently(Concessionaire/ Contractor) had awarded the work for Design, Supply and Technical Assistance to..... (Technology Provider) vide Sub-Contract No..... dated..... for the.....

The scope of work has been defined in the Sub-Contract vide reference no..... dated.....

Both the Concessionaire/Contractor and the Technology Provider shall execute the Project as per their respective scope including the terms and conditions as defined in the Sub-Contract vide reference no..... dated.....

The Technology Provider shall be responsible for the design of the..... structures. The Concessionaire/Contractor shall be liable for providing the design inputs based on which the Technology Provider shall design thestructures and issue the construction drawings

The construction work shall be carried out by the Contractor or the Technology Provider as per the provisions of the Sub contract between the Contractor & the Technology Provider in strict conformance to the Construction Method Statements issued by the Technology Provider

The Sub Contract between the Contractor & the Technology Provider shall provide for the deputation of trained construction supervision personnel for the duration of the project. The Technology Provider shall have the full authority stop the work and escalate the matter in case of any violations related to:

1. Construction Method Statements
2. Safety
3. Drawings & Specifications
4. Quality of backfill & quality / degree of compaction
5. Any other associated quality related to installation and construction work

IN WITNESS WHEREOF the parties have here unto set their respective hands and signature, the day and the year first above written, SIGN ED AND DELIVERED BY THE

Name

On behalf of Concessionaire/ Contractor

SEAL ADDRESS

.....

.....

In Presence of:

Name:

Address

Name

On behalf of Technology Provider

SEAL ADDRESS

.....

.....

.....

In Presence of:

Name:

Address

Enclosure: Sub-Contract Agreement vide reference no.....dated.....