

USE OF REINFORCED EARTH STRUCTURE IN RAILWAYS



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SYNOPSIS

A New system for using earthy materials for construction made its appearance fairly recently. Owing to its similarity with the coupling of concrete and its steel reinforcement a new system has been invented in France by Henry Vidal and Scholsser in 1960 and gave a suggestive name of **Reinforced earth**.

This technique consists of reinforcing the earth with horizontal metal elements extending from a thin facing of concrete or steel, into a suitable backfill to form a retaining wall. This technique can result in saving in areas where full side slopes cannot be adopted, such as built up areas, Ghat section with sidelong slopes and also on poor soils where foundation for conventional retaining wall is costly.

Though this technology is new in Indian Context, some of the Infrastructure Development companies are now using this technique for ROB's. However this technology is not used for railways in India, but has a potential of its use. This presentation will put light on basic concept, design and specification for materials with some example of its use for railways.

1. Introduction:

Reinforced earth is a combination of earth and linear reinforcing strips that are capable of bearing large tensile stresses. The strips or linear elements are usually of metal or plastic. The reinforcement provided by these strips enable the mass to resist the tension in a way which the earth alone could not. The source of this resistance to tension is the internal friction of soil, because the stresses that are created within the mass are transferred from soil to the reinforcement strips by friction.

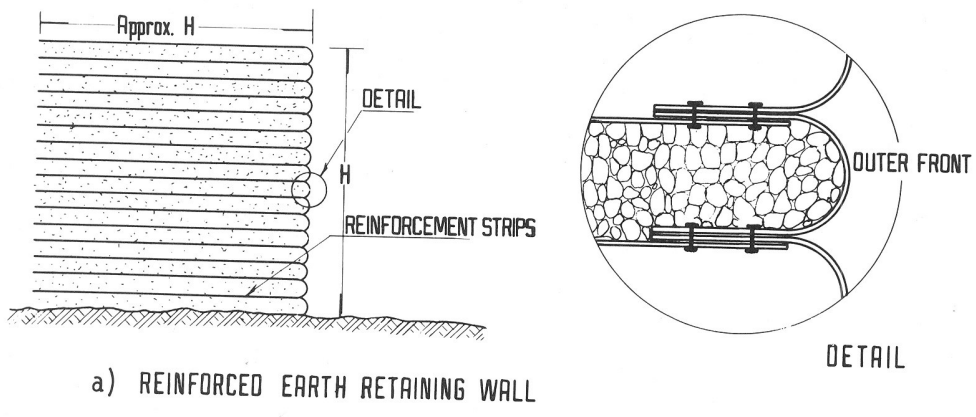


Fig shows the arrangement of the reinforcement strips and details of the joints.

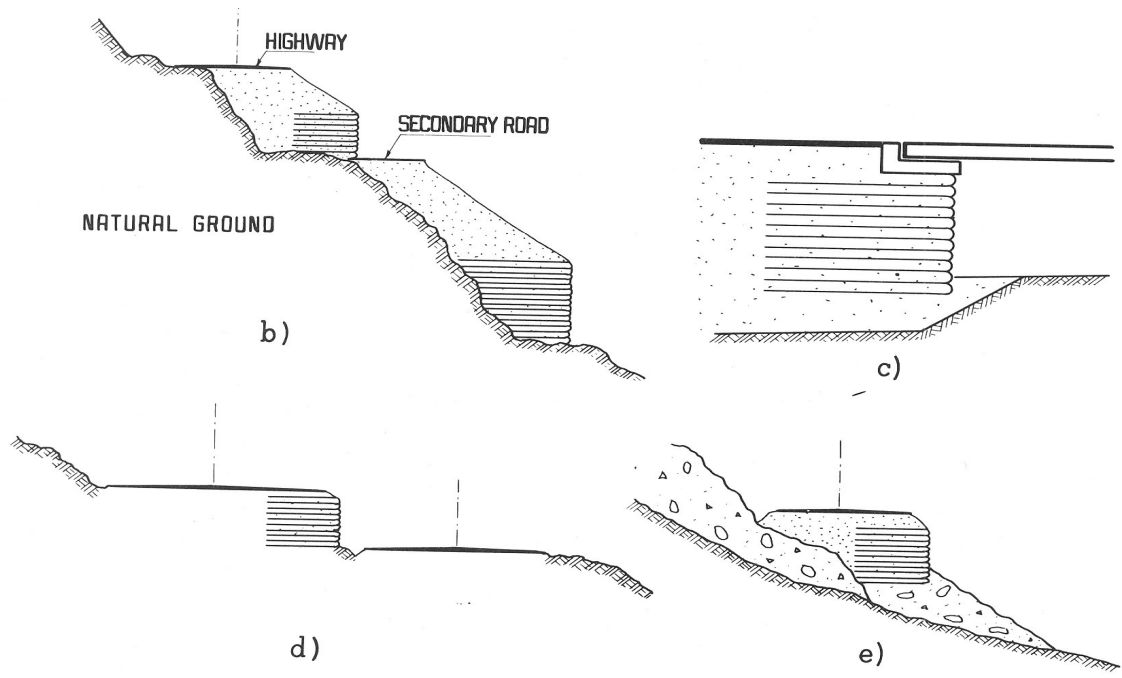


Fig shows the locations where the R.E. Wall is suitable.

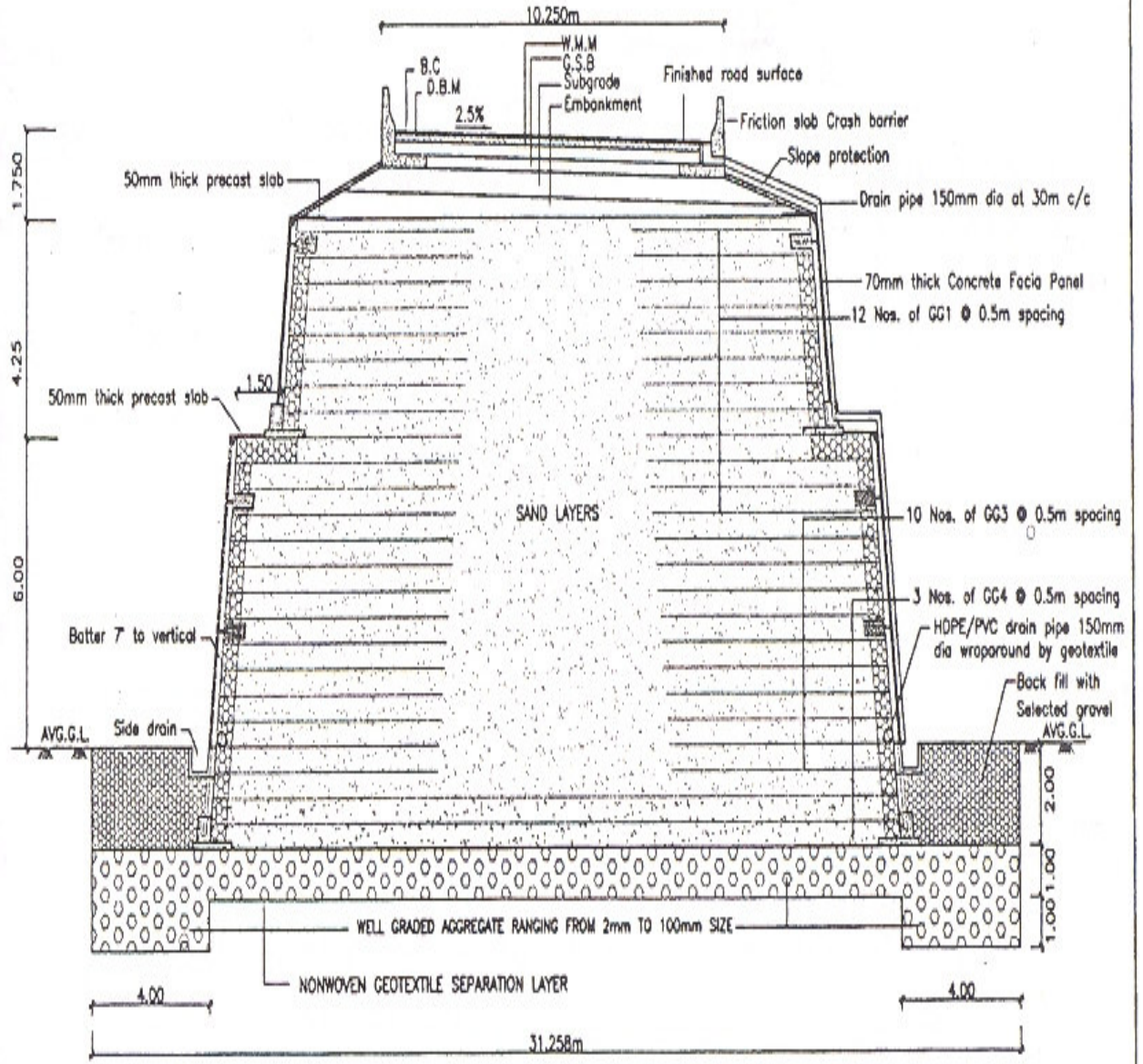


FIG.3. TYPICAL CROSS SECTION OF REINFORCED SOIL WALL

Components of Reinforced Earth

1 Reinforcing Fill

Any suitable well graded granular material which is able to develop sufficient friction between reinforcing material and soil. Generally it should be granular, cohesion less material, should have very less amount of reinforcement corroding elements.

2 Retaining Fill :

Normally same fill material as in the reinforcing fill may be used but not mandatory. Material with some inferior quality can be used. In such case the design earth pressure on the facing element will increase it needs to be designed for that increase pressure.

3 Reinforcing Material:

Reinforced members are composed of thin wide steel or aluminum strips called **ties**. The flexibility of reinforcing strips and their tensile strengths are essential elements.

Other types of polymeric material which can be used as reinforcement are

1. **Geotextile:** Geotextile in fabric form are being used as a **basal** reinforcement of embankment and fills on the ground
2. **Geogrids:** These are made up of High Density Polyethylene (HDPE) and interconnected longitudinal and transverse Member. These are made from sheets of polymer by punching holes and stretching the sheets in one or two direction.
3. **Geogrids:** which are made up of High Modulus Polyester Fiber (PET)? These grids are made from weaving polyester fiber into high tensile yarns and forming interconnected members.

All polymeric reinforcement is normally provided with a black coating to protect it against an Ultra Violet rays.

4 Facing Element :

Facing Element form the outer skin of the reinforced soil wall. These elements keeps the reinforcement at a desired elevation in the reinforced soil wall and also protect the granular at the edge falling off. A large variety of facing elements are in use. Panel Blocks and wrap around system are of common use. The choice depends upon the type of reinforcement used. Panels are used with HDPE reinforcement, while normally blocks are used where with PET reinforcement. Facing element can also be given an attractive pattern and finish to enhance the architectural appearances of the reinforced soil wall.

5. Draining Layers:

Reinforcing soil derives its strength from frictional interaction between the soil fill and reinforcement hence keeping the soil fill fully drained ensures the wall in better stability. Although the fill material is specified a free draining it is desirable to keep the drainage layer at the face of reinforced soil wall.

6. Footing:

Where soil has adequate bearing capacity a concrete pad footing is provided. In case facing panels are used footings may be made of trough shaped to

allow for the small rotation of the panel during and after the construction of wall. Level concrete footing is adequate for Block type Facia or wrap around facing.

7. Basal Reinforcement:

Where subsoil is clayey and does not have adequate bearing capacity, basal reinforcement is adopted. The Basal Reinforcement has to be of adequate width. The required width of the basal reinforcement is usually more than the width of the reinforced soil structure. (i.e. the width between two face walls.) The width required depends on the thickness of the clayey layer as well as the required factor of safety against the failure in bearing capacity.

Stability of a reinforced earth retaining wall

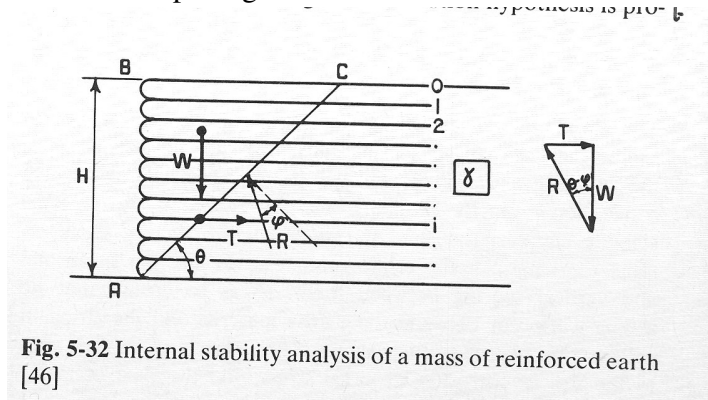
Stability of a retaining wall built with reinforced earth should include two types of analysis

1. **General Analysis :** General analysis of the structure shall be not different than the conventional gravity retaining wall. General analysis is performed for checking the external stability of the structure. In these analysis the factor of safety against possible failure by 1) sliding at the base. 2) Overtuming about the toe. 3) Excessive bearing Pressure and 4) Excessive settlement of the structure , will be checked.

MINIMUM REQUIRED FACTORS OF SAFETY

Failure Mode	Load Combination		
	Static Only	Static + Seismic	Static + Drawdown
Sliding	1.5	1.1	1.2
Overtuming	2.0	1.5	1.5

2. **Internal Stability Analysis :** The Chief purpose of the internal stability Analysis is to determine the length of the reinforcing strips and horizontal and vertical spacing between them.



Above figure shows the procedure suggested by Vidal and Schlosser for computing the internal stability of the mass of the reinforced earth. For a mass of a reinforced earth nearly a rectangular cross section is recommended where a width is approximately equivalent to height of the wall. The surface A-C limits the wedge of the reinforced earth. Its equilibrium can be analyzed by expanding on the ideas governing the coulombs method for conventional case of earth thrust.

Design of Components:

Design of the skin: The design of the skin elements is simple, once the lateral earth pressure has been calculated. Normally the required thickness of the curved element is small, too thin for practical installation and additional material is required for higher factor of safety and protection against corrosion. The design of skin is based on the principles of design of thin shell.

Design of Tie: The key features and dimensions pertaining to the ties are shown in Fig. 5

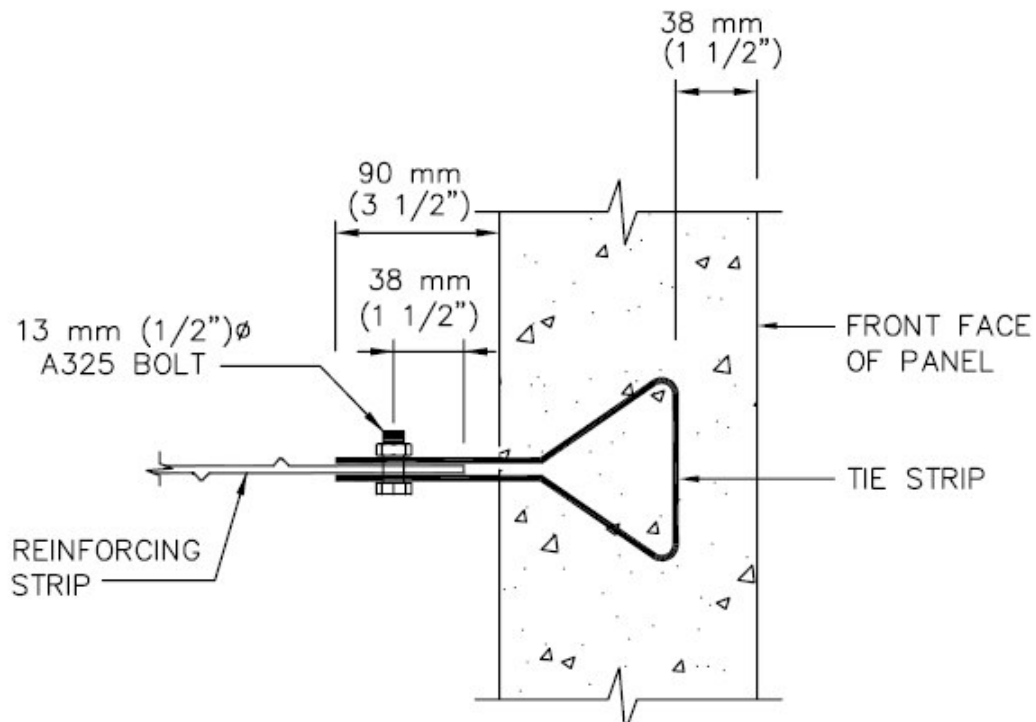


Fig 5 shows the typical arrangement of tie with the facing material

It is assumed that the wall is perfectly flexible and frictionless. If the wall is made of rigid skin element, then the effect of wall friction will lead to slightly lower active earth pressure than assumed herein. It is further assumed that the wall will move laterally during construction by sufficient amount to mobilize a state of active earth pressure in the soil behind. This movement results from the relative displacements needed to mobilize the skin friction between the soil and ties. Thus the lateral earth pressure against the wall is assumed to increase linearly with depth.

The ties are designed specifying the following criteria:

The ties must be strong enough to prevent failures by breaking in tension (tension mode of failure).

The ties must have sufficient contact surface to develop adequate friction to prevent failure by pulling out (bond mode of failure).

The tensile force in the tie element increases from zero at the free end to maximum at the face of the wall, like the earth pressure distribution. The tensile force also increases linearly with depth.

Selection of Materials for Components:

Soil:

4.2.1. The selection of the soil intended for a reinforced earth structure is based on technical as well as economic considerations. The soil must be able to develop friction. Since the friction between the soil and the reinforcement is a fraction of the angle of the internal friction of the soil. The design of a reinforced earth structure requires that the earth reinforcement coefficient of friction to be either higher than or equal to 0.4. This makes it necessary to avoid soil with too much clay content, and necessitates the establishment of simple criteria to be used in the selection of reinforced earth backfill material.

Minimum specification for selecting backfill:

Sieve size % passing

150 mm 100

75 mm 75-100

0.2 mm 0-25

And Plasticity Index < 6.

Facing elements: The facing is made of either metal units or precast concrete panels which are easy to be handled and quickly assembled

Metal facing: Metal elements are manufactured from mild or galvanized

steel and have the same properties as those of reinforcing strips. In cross section, it is semi-elliptical and there is a continuous horizontal joint along one edge. Holes are provided for bolting the facing elements to one another and to the reinforcing strips. Because of the shape in profile and the thinness of cross section, it can adopt itself to significant deformations.

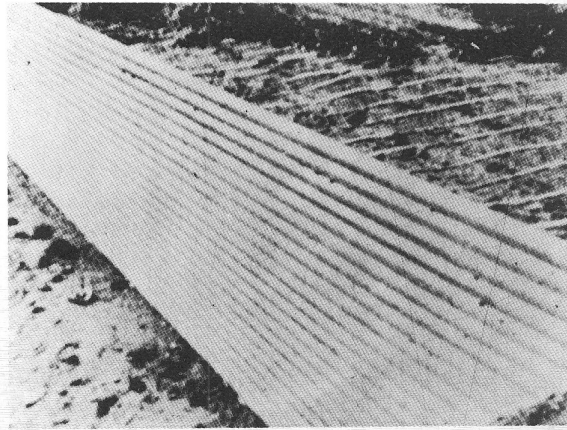


Plate 5-10 Example of situation where reinforced earth is used

Concrete panel facing: The precast concrete panels are cruciform shaped and are separated by a substantial joint.



Panel installation

Reinforcing Strips: The reinforcing strips are made of mild galvanized steel, stainless steel or aluminum alloy. Bolts and nuts for fixing the ties are made of the same material as that of the reinforcing strips. The durability of the strips depends on the chemical and electro-chemical behavior of these metals when in contact with soil particles.

Compaction:

Compaction is not essential to the stability of a reinforced earth structure, but it is necessary wherever there is need to minimize settlement within the structure, as in the cases where the structure will support a highway or carry concentrated loads. Structures such as walls for gardens and terraces and protective walls for revetment have been built without compaction. When reinforced earth is used in road construction, the earth fill material is compacted in a manner similar to that of an ordinary embankment. In order to avoid disturbance to the facing heavy compactors should go no closer than two meter to the wall facing. The area close to the facing should be compacted with light compacting equipment.

Durability of the Reinforced Earth structure:

As the durability of the R.E. Structure depends upon the properties of the components of the RE Structure. Such as durability of reinforcing Material as well as frictional properties of the Fill soil used.

Conclusion :

As there are Presently Not many literature is available particularly with regard behavior of RE Wall to Railway Loading . Even Very Few countries codes are specifying about the RE Structure. Hence there is a need to study the Behavior of RE Structure under Railway Lading, with some Model / Prototype Study and Update the Codes Specifying the Railway Loading

References:

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