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Reinforced Earth Wall-Causes of Failure and Remedy

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Abstract: Reinforced Earth Wall (RE Wall), is a composite material formed by cohesion less soil and flexible metal/geosynthetic reinforcing strips. Construction of a Reinforced Earth wall is straightforward and simple. Merely place a layer of facing panels, bolt on the metal/geosynthetic reinforcing strips then backfill and compact. During the rainy season, it has become common to hear about the failure of RE wall, consequently disrupting the traffic. There are various causes for failure like bowing, bulging and tilting, unfortunately the user of road/highway suffers a lot in terms of inconvenience. This paper analyses the causes of failure, effects and remedy, to minimise and avoid these failures, by keeping suggested remedies during the design, construction and maintenance stage, by implementing good industry practices, during design, construction and maintenance stage

Keywords: RE Wall, Geosynthetics, Hydrostatic pressure, Facia panel, Drainage system

I. INTRODUCTION

1. RE WALL - CONSTRUCTION STEPS

The performance of the RE Wall hinges depends not only on design but to a larger extent on the care and accuracy to which the construction is carried out. The Construction of RE Wall should be therefore given due importance especially since it involves layer wise construction.

The responsibility of the construction of a RE Wall will solely lies with the EPC-Contractor. However, the following steps are to be followed for construction of RE Wall:

1.10 Foundation treatment, if required, shall be first completed to ensure that design parameters are attained. It should be noted that use of RE Wall does not imply that no foundation treatment is required

1.11 The plan of the RE Wall shall be marked on ground as per approved drawing/design.

1.12 Excavate and compact the base of the ground to the embedment depth and required width, to a dry density of 95 percent of the Modified Proctor Density.

1.13 The trench shall be backfilled using reinforced fill, levelled and well compacted to achieve 95 percent Modified Proctor Maximum Dry Density. An initial levelling pad of 150 mm thick using (minimum) M15 plain cement concrete having suitable width to be placed below the first row of fascia layer.

1.14 The first layer of face block or element is placed on the base and level envisaged in the drawing.

1.15 The alignment of the block/facing element must be checked regularly to make sure the wall is straight or curve as per approved drawing/design.

1.16 The required thickness of drainage material shall be placed at the back facing block/panel and in the hollows effacing block. The drainage material shall be compacted with vibratory plate compactor and within the block cavities. No heavy compaction equipment should be allowed to operate within 1.5m of the back of face panel.

1.16 Placing the reinforced soil backfill behind the drainage zone and compacting to a minimum of 95 percent Modified Proctor density/80 percent Relative Density. The backfill should be placed and compacted in layers. The compacted thickness of each layer shall not exceed 200 mm. At no stage of construction, the compaction or any other equipment shall be allowed to operate directly on the reinforcement.

1.17 When in direct contact, the backfill material and the drainage material shall be separated using permeable non-woven geotextile.

1.18 The successive face element shall be placed as per required line and level. In several cases outward movement has been observed due to poor connection of reinforcement with face element. Provisions given in approved design/drawings should be followed. The same procedure shall be repeated until the final layer of reinforcement is reached.

1.19 Before placing the drainage material and backfill, the reinforcement should be cut to length and placed on top of the face block. The reinforcement should be stretched to ensure that there are no wrinkles and the reinforcement is taut.

1.20 Care should be taken to ensure that geo-grid is slightly away from the external junction of outside face of fascia block. This will ensure that the geo-grid does not protrude out of the wall and is prevented from UV ray exposure.

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1.21 Second layer of facia block is laid over the geo-grid, so that geo-grid is completely interlocked between the blocks. The above procedure is repeated for subsequent geo-grid layers.
1.23 Where panels are used, the reinforcement should be connected to connector embedded in the panel. The connection envisaged should be clearly indicated in the approved design and outlined in the "good for construction drawings". At no stage of construction, the details envisaged in design should be changed.
1.24 When panels are used it is desirable to keep an initial inward better. It should be in accordance with drawing/design/specifications, which states that it may be necessary to 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.
1.25 Where the retained fill is borrowed and is different from the reinforced fill, the construction should progress simultaneously.

II. COMMON CAUSES OF FAILURE OF RE WALLS

Design and construction of Reinforced Earth walls is an involved process requiring due diligence and quality control. Moreover, repairs and remedial measures are often laborious, difficult, time consuming, expensive, often ineffective in the long run and in most of the cases impossible to implement. The designer and the owner should therefore be cautioned that while there are several advantages of using RE Walls these are not realised unless careful consideration is given to design as well as construction procedures. Failures can be in serviceability as well as collapse. Common causes of distress and/or failures are summarised in Table-01, with possible remedial measures.

Table - 01

S.No	Causes	Effect	Remedial measures
1	Inadequate Investigations regarding founding soil - typically erroneous or inadequate data for classification, shear strength, stratification	Excessive differential/total settlement resulting in Bulging/leaning of face panels and uneven riding surface in plan, bearing capacity failure leading to excessive distortion or collapse	Adequate detailed investigation should be done for foundation to ensure the safe bearing capacity.
2	Inadequate investigations regarding borrow area material to be used as reinforced soil; typically data which would give reliable and consistent knowledge regarding shear strength and permeability properties of the entire borrow area fill	Difficulty in compaction, Build-up of hydrostatic pressure if the fill contains high percentage of fines resulting in bulging and/or leaning of fascia.	Detailed investigations should be done regarding borrow area material to be used as reinforced soil and its properties as mentioned in approved drawing/ design/specifications.
3	Inadequate inputs regarding reinforcement properties - typically data for creep, strength etc.	Excessive strain in the reinforcement resulting in bulging and or/local failures in the long run.	Adequate details about reinforcement properties - typically data for creep, strength etc.; as mentioned in approved drawing/design /specifications
4	Inadequate drainage bay design to ensure drainage from retained fill	Excessive hydrostatic pressure/development of pore pressure resulting bulging and/or leaning of fascia.	Adequate drainage bay design to ensure drainage from retained fill, to make safe and secure passage for water
5	Inadequate/improper levelling pad construction as far as material, level etc. is concerned	Excessive settlement resulting in distortion/ leaning of the wall, and uneven riding surface Clogging of drainage pipes	Adequate/proper levelling pad to be constructed as far as material, level etc, is concerned, as per approved drawing/design/specifications

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6	Compaction not meeting specifications Reinforced fill not meeting specifications in gradation, permeability plasticity characteristics etc.	Leaning and eventual collapse of panels/blocks leading to local failures/bulging of walls	Adequate Compaction not achieved. Reinforced fill not in gradation, permeability plasticity characteristics etc. asper approved design /drawing/specifications
7	Improper drainage details like perforated pipe details, laying, location in plan and elevation, outlet levels, etc. Improper Connection to fascia at variation with respect to specifications /drawing Heavy Compaction equipment coming within 1 .5 m of the face of the wail. Drainage bay material not meeting specifications Initial batter not provided in panels	Panels not battered sufficiently. Large backfill placing, Backfill material placed wet of optimum moisture content. Backfill contains excessive fine materials. Backfill material pushed against back of wall before being compacted on strips. Excessive or vibratory compaction on uniform fine sand. Backfill material dumped close to free end of reinforcing strips, then spread towards back of wall, causing bulge in strips and pushing panel out. Plasticity index of backfill material in excess of specification limits	Adequate and proper drainage details like perforated pipe details, laying, location in plan and elevation, outlet levels, etc. to be provided Proper Connection to fascia at variation with respect to approved specifications/ drawing, to be provided Avoid heavy Compaction equipment - within 1 .5 m of the face of wail.
8	Normally, RE Walls are not designed for hydrostatic pressures.	Excessive settlement resulting in distortion/ leaning of the wall, and uneven riding surface Clogging of drainage pipes	Where hydrostatic pressures are likely due to submergence; the design should account for such pressure. To ensure that these conditions are realised in the field, adequate drainage measures need to be taken

III. CONCLUSION

3.10 Selection and approval of borrow area with respect to specified parameter is very important, for the stability, and performance of RE Wall.
3.11 Proper supervision and material tests as per frequency are required to be performed
3.12 Construction supervision of the workmanship during the construction of RE Wall is quite important
3.13 Proper supervision of layer wise compaction during the construction of RE Wall is quite significant

IV. RECOMMENDATIONS

4.10 The construction of RE wall should progress with strict quality control, in respect of men, material and plant
4.11 The care should be taken while erection of panel, so that EPDM is not dislocated from its specified position**.**
4.12 During erection of panels, wooden clamps with tie rods, wedges and temporary supports are provided, wherever required
4.13 The 3-Dimensional drainage plan should be used for ensuring proper drainage during heavy rains.
4.14 The provision of hydrostatic and hygroscopic pressure, should be accounted for in design for heavy rainfall zones.
4.15 Small walk-behind vibrating rollers or flat-plate compactors are needed for compaction within 1.50m of facing panels

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