Reinforced Soil Walls: Rebuilding Confidence

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SYNOPSIS

India has undertaken large infrastructure up-gradation projects and Reinforced Soil Walls are being widely used for retaining high embankments. With burst of activities, some hard experiences are bound to come by. Incorrect implementation of the design and construction practices has given the technology a bad name. Also the general feeling with the contractors is that this is a resource intensive technique coupled with underutilisation of the same. Many highway projects have got delayed due to non-timely completion of reinforced soil structures. The unfavorable scenario is also preventing any innovation to see the light of the day which, in addition to preventing some of the failure modes, can also possibly simplify the construction a lot.

1. INTRODUCTION

1.1 India has undertaken large infrastructure up-gradation projects and Reinforced Soil Walls are being widely used for retaining high embankments due to various reasons such as limited ROW, to minimize land acquisition, poor founding soil conditions, economy and aesthetic considerations etc.

1.2 Reinforced soil is an internally stabilized composite engineering mass, consisting of selected backfill, soil reinforcing elements and a non-structural facia.

1.3 Facing is a component of the reinforced soil system used to prevent the soil from raveling out between the rows of reinforcement. Few incidences of panel separation have been noticed in the recent past. In addition facia alignment control is a big challenge during construction and requires lot of care and skilled manpower.

1.4 Although the reinforced soil mass is a flexible mass and can tolerate lot of total and differential settlements making it a good option for poor founding soil conditions, global stability still needs to be checked for avoiding deep seated failures.

1.5 Other possible failures are breakage of reinforcing elements, pullout of the reinforcing elements, direct sliding failure, facia interlocking/cracking & excessive deformation

of the reinforced earth mass resulting in loss of batter &/or negative batter.

1.6 In addition the general feeling with the contractors is that this is a resource intensive technique coupled with underutilisation of the same, specially the earthwork equipment.

1.7 All the above factors have caused a fear/ apprehension/ resistance in the mind of the 3Cs (viz. Client, Consultant and Contractors) and all efforts are being made to avoid use of reinforced soil walls, wherever possible.

1.8 In order to re-generate confidence, a possible concept has been presented for composite construction with in-situ RCC facia (similar to conventional RCC walls) and reinforced backfill.

1.9 In view of the author this can expedite the construction a great deal, as some of the execution process bottlenecks can be dispensed with. This shall result in contractors getting better output of their resources and avoid possible project delays. In addition, the failure mode of facia separation and possibly the negative batter development can also be prevented by its usage.

2. SOME SETBACKS

2.1. Facia Separation

This is the most common type of failure which has been experienced and documented worldwide including India. By its inherent nature this is not a failure of the reinforced earth mass but a loss of skin to the mass due to various reasons. Excessive rainfall has been a major cause of distress due to pore water pressure development coupled with sand blow through the facia joints. Differential settlement occurs on account of soil loss and/or poor compaction of backfill, resulting in reinforcing element- facia connection snapping. External damage to the facia can also cause this type of failure. Few of the photos given below represent the failure.

Photo 1 and 2: Two Cases of Facia Panel Separation

Photo 3 and 4: Two Cases of Modular Block Separation

Photo 5: Case of Sand Loss Due to Rainwater

2.2. Deep Seated Failure

This type of failure is not very common and can result only in case of very marginal founding soil conditions. Few of the photos given below represent the failure.

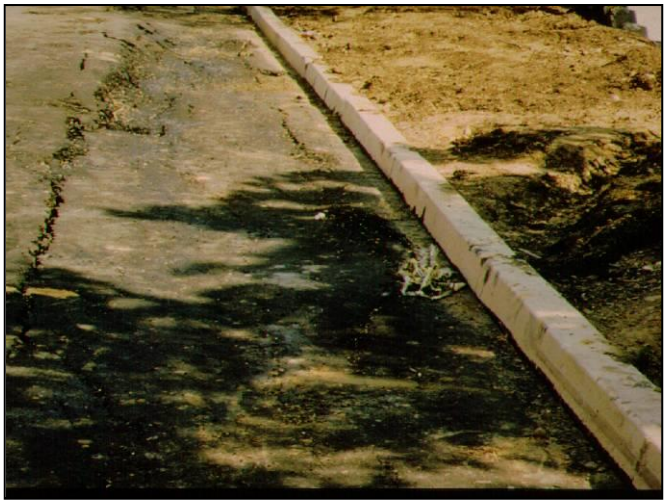
Photo 6 and 7: Case of Deep Seated Failure

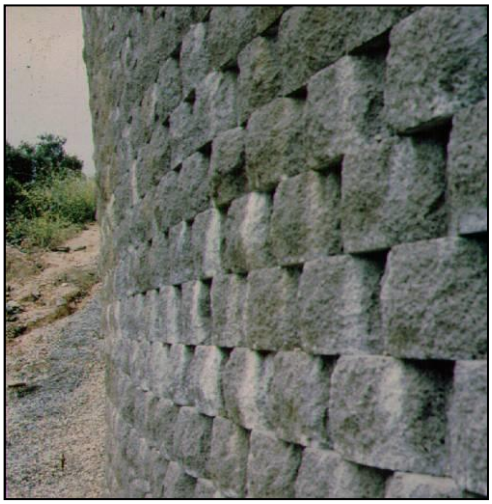
2.3. Other Types of Failures

The other types of failures possible are breakage of reinforcing elements, pullout of the reinforcing elements, direct sliding failure, facia interlocking/cracking and excessive deformation of the reinforced earth mass resulting in loss of batter and/or negative batter.

However, in the opinion of the author the first three of the above possible failures are rare and is unaware of any such actual incidence. The last of the above is a distinct possibility and has been experienced in India as well. The prime reason seems to be design coupled with poor workmanship, wherein possibly the strength requirement as well as the interaction parameters may have been wrongly assessed.

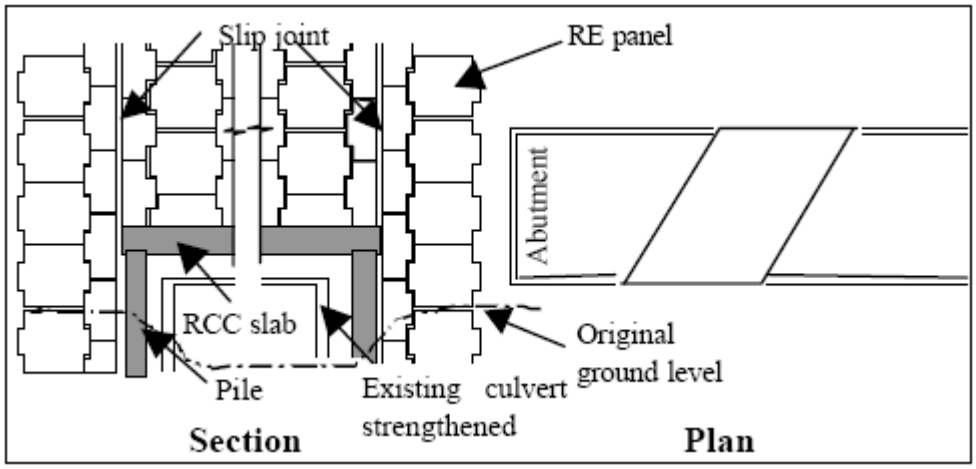
Photo 8, 9 and 10: Case of Negative Batter Development





Facia interlocking can occur in case the founding media is having widely varying settlement characteristics. Commonly encountered problems of (i) the positioning of the cross walls behind the abutments with pile foundation and (ii) cross over of a RCC slab/culvert as shown below. The solution lies in providing a vertical slip joint at all such transition points.

Fig 1: Provision of Slip Joint to Prevent Facia Interlocking



3. RE WALL FACIA

1.1 Facia, which is the skin of the RE mass and is a non-structural component of the whole system, is a source of numerous problems viz.

- reduces the RE mass' settlement capacity limiting its usage potential on poor founding soils
- gives rise to facia un-stability under differential settlement between the backfill and self,
- cannot control any unwanted deformation of the backfill resulting in facia alignment irregularities,
- discrete panel joints is a source of possible sand blow, and
- non-uniform joints and poor alignment can result in bad looking structure

3.2 It is well known fact that, facia alignment control is a time taking activity during erection of the reinforced soil walls. In addition, the laying of reinforcing elements, filer media coupled with facia placement and alignment, results in lower utilisation of the earth work equipment to the tune of 50%, as compared to normal embankment construction.

3.3 There is a need to evolve a facia system, which can address the above issues, without compromising with the aesthetics and economics of the structure, which is a major reason for the introduction of reinforced soil walls.

4. POSSIBLE INNOVATIONS

4.1 It is suggested to use in-situ RCC facia, which is designed with a foundation system and stem capable of sustaining a certain amount of earth pressure.

4.2 The backfill is reinforced to the desired degree with the reinforcing elements. The reinforcing elements are not connected to the facia thus there are no fixtures required on the internal face of the in-situ RCC skin.

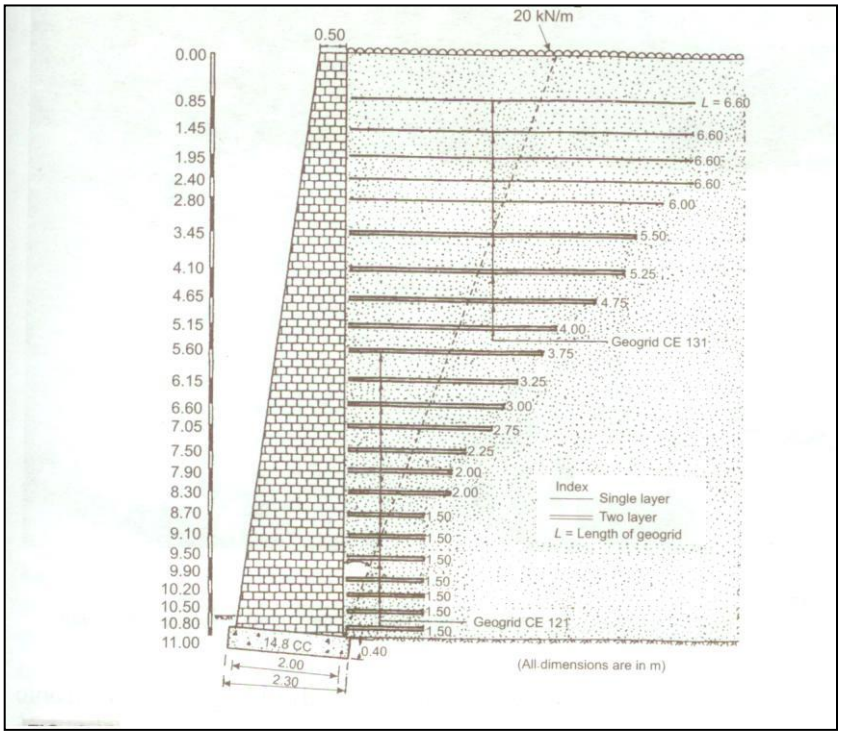
4.3 The construction of RCC skin can be started in segments and without waiting for the full width to be available. This is great advantage in many urban situations, where complete traffic diversion is delayed for various reasons. Please note that there is earthwork activity yet.

4.4 There are no weep holes required in the facia, as an alternate drainage arrangement can be installed at the skin's back face using a variety of geo-composites available.

4.5 Aesthetics of the in-situ skin can be improved by using form liners, which are being used in a big way to improve the outlook of exposed concrete surfaces.

4.6 After completion of the facia construction, the earthwork is started and is interspersed with reinforcing element's layers, as per design.

Photo 11: A Sample Hybrid Construction (with masonry facia)



4.7 It is worth noting the simplicity introduced due to the following facts:

- There is no waiting for the facia placement, its alignment etc.
- Special moulds for precast facia, precasting and its transportation are eliminated
- The requirement of erection accessories is eliminated
- The laying of the reinforcing elements is simplified, as these are not to be connected to the facia
- There is no separate filter media required, which is a time taking activity
- The precaution required in rolling the backfill, specially near the facia, is absent
- The baby roller/ plate compactor can be dispensed with
- No specially skilled manpower is required to undertake the job

- In addition, the expensive friction slab can also be eliminated
- The crash barrier construction does not require the gap around the facia and hence can be constructed faster

4.8 Following limitations are expected:
- Additional cost is required for in-situ facia construction on account of foundation and reinforced stem
- Formwork cost shall be higher in order to achieve better finish

4.9 The author feels that the above shall result in the reinforced soil wall construction technique becoming contractor friendly in a big way. At present lot of contractors avoid / delay construction of RS walls since not only a large no. of resources are required simultaneously, these are also underutilized during construction.

4.10 Segregating the facia construction and backfilling can simplify the process of reinforced soil walls construction a great deal, in addition to the inherent advantage of avoiding many modes of failures highlighted above.

4.11 Actual field work needs to be undertaken in order to assess its economics, constructability and acceptance by the fraternity.

5. CONCLUSIONS / RECOMMENDATIONS

5.1. Possible RS wall failure modes viz. facia separation and negative batter can be eliminated by use of in-situ RC facia with reasonable bending strength.

5.2. The author feels that the above shall result in the reinforced soil wall construction technique becoming contractor friendly and avoid delays in project completion on this account.

5.3. Actual field work needs to be undertaken in order to assess its economics, constructability and acceptance by the 3Cs fraternity.