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Reinforced Earth Wall - A Case Study

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***Abstract* - Reinforced soil is a composite construction material formed by combining soil and reinforcement. This material possesses high compressive and tensile strength similar, in principle, to the reinforcement cement concrete. It can be obtained by either incorporating continuous reinforcement inclusions (for example: strip, bar, sheet, mat or net) within a soil mass in a definite pattern or mixing discrete fibers randomly with a soil fill before placement. The term 'Reinforced Earth Wall'. Geosynthetics are widely used as structural reinforcement in steep slopes, retaining walls, embankments over soft ground and road base reinforcement. The application of geosynthetics in civil engineering has been more than 40 years. Since then, it has been widely used in civil engineering practices.**

Keywords: Soil reinforcement, Reinforced Earth Wall, Tensile Strength, Geosynthetics, Reinforcement, Retaining Walls.

I. INTRODUCTION

Reinforced earth is a combination of earth and linear reinforcing strips that are capable of bearing large tensile stresses. Reinforced soil is a soil which is reinforced with artificial materials, like sheets or strips of galvanized steel or geotextiles, in desired directions so that it acquires many novel characteristics, which renders it eminently suitable for construction of geotechnical structures.

The concept of soil reinforcement was introduced in 1966 by Henry Vidal, a French architect and engineer. Since then, it has been widely used in civil engineering practices. The principle of reinforced soil is analogous to that of reinforced cement concrete. In the early stages of its development, steel and iron in form of nails, mats, grids or strips were used. Owing to its many practical difficulties, the applicability of the principle was largely reduced.

Four decades ago, the engineering field saw an influx of geosynthetics into its foray. The utilization of geosynthetics offers excellent technical, economic, environment-friendly and energy-efficient alternatives to the conventional solutions for many civil engineering problems.

1.1 Concept of Soil Reinforcement

Reinforced soil is a composite material formed by the association of frictional soil and tension resistant elements in the form of sheets, strips, nets or mats of metal, synthetic fabrics or fibre reinforced plastics and arranged in the soil mass in such a way to reduce or suppress the tensile strain which might develop under gravity and boundary forces. The improvement to the total system energy is achieved by the following three mechanisms:

a) Lateral restraint due to inter-facial friction between the soil aggregates and reinforcing material.
b) Forcing the potential failure plane to develop at an alternative higher shear strength surface.
c) Offering a membrane type of support to the wheel loads.

II. MATERIALS

Components of Reinforced Earth Wall

1. Soil
2. Face element
3. Reinforcement

2.1 Soil for Reinforced Earth

i. It should be granular, cohesion less material, silt or clay having particle size not more than 125 mm.
ii. Not more than 10 percent of the particles shall pass 75micron sieve and the earth reinforcement coefficient of friction to be either higher than or equal to 0.4 & plasticity Index < 6.
iii. The soil must have a moisture content suitable for compaction.

2.2 Skin for Reinforced Earth

i. Skin is the facing element of the reinforced soil wall.
ii. These elements support the backfill and keeps the reinforcement at a desired elevation in the reinforced soil wall and also protect the granular at the edge falling off.
iii. Made of either metal units or precast concrete panel.
iv. The precast facing panels are typically 160-180mm thick.

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2.3 Reinforcement

A Variety of materials can be used as reinforcing materials such as:

- Steel
- Concrete
- Glass fiber
- Wood
- Rubber
- Geo-synthetics

III. METHODOLOGY

Design of Reinforced Earth Wall

3.1 Earth work excavation

Excavate the formation to the required level as shown in the construction drawings. The surface of formation should be free from any deleterious material and unwanted foreign object. Loose pockets if any, shall be excavated and filled with suitable granular material. Roll the formation using vibro-roller of 8 – 10 tones capacity.

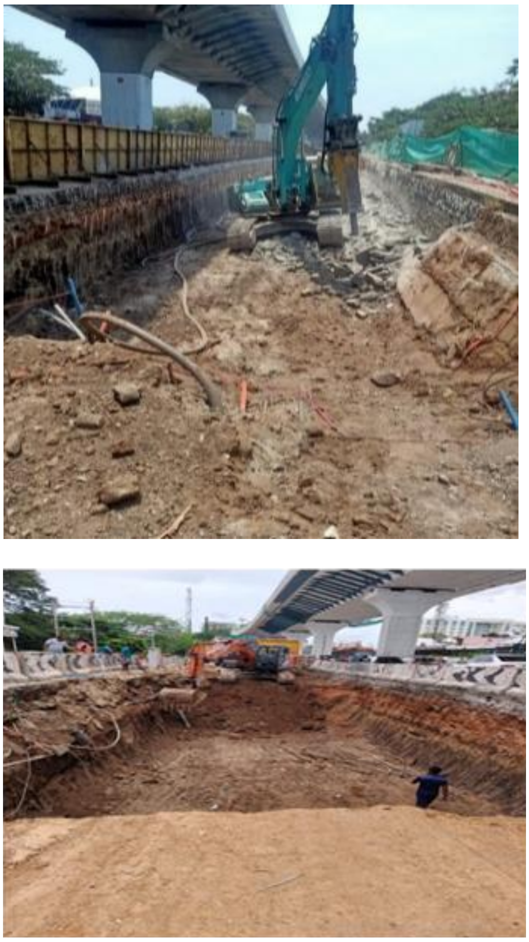

Figure 3.1: Depth of Earth Work Excavation

3.2 Leveling pad

Leveling pad is cast-in-situ PCC (M20) of 450 mm width and having minimum thickness of 200 mm. The leveling pad provides leveled surface for the panel and should be cast within a tolerance of ±5 mm with respect to levels indicated in the drawing.

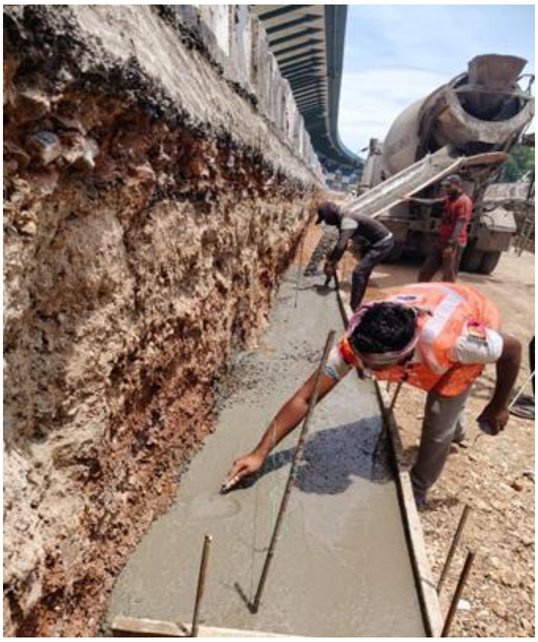

Figure 3.2: Checking of levelling pad

3.3 Wooden clamps and wedges

This are used to hold the panels in place during the construction of reinforced soil wall. Wooden clamps comprise of two wooden blocks a MS steel rod of 12mm diameter and 425mm length passing through the wooden blocks.

3.4 Joint Fillers (Vertical and horizontal)

Non-woven geo-textile are pasted/ fixed on horizontal and vertical joints to prevent the loss of backfill soil / aggregates through the joint.

If the foundation soil does not meet the above requirements, then the ground should be improved vicely using ground improvement methods. Here we are excavating the OGL soil up to required depth as per designer recommendations and it is replaced by the backfill soil in a layer-by-layer manner with a proper compaction.

Filling, Grading and Compacting of soil

- Filling can be proceeded in layers with required thickness shall be marked on the panel at definite interval.

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- The filled material should be spread by grader machine uniformly until a proper leveled surface attained.

Figure 3.3

- After leveling compaction of soil has to be done by using heavy earth compactors (8-10KN) to the required density (97% of MDD).
- Geo-textiles
- Geo-grids
- Grids made up strips
- Geo-straps
- Geo-straps are mainly designed to construct the reinforced soil wall for the approaches to flyovers, underpass, road/rail over bridges. Bridge abutments and wing walls, highway and railway embankments.

3.5 Laying of paraweb

Commence laying the paraweb of specified grade by looping it around the rear bar allowing a 2.0m overlap.Paraweb shall be passed through the connector by looping around the bar inside the connector. When all the paraweb has been loosely laid out adjust the spacing of the paraweb at the rear end.

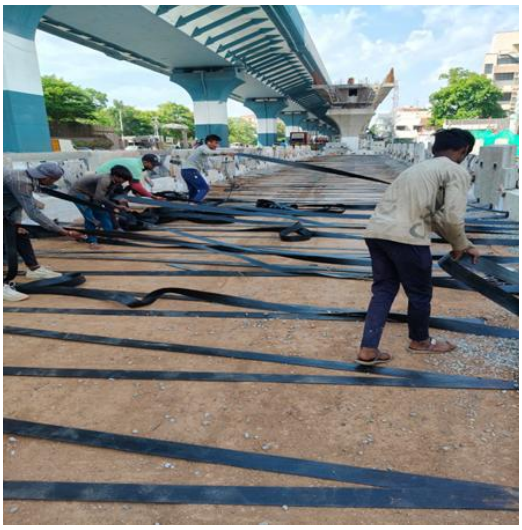

Figure 3.4: Laying of para web

To connect two lengths of paraweb a lap joint is formed in the rear end of the structure. The lap should be 2.0m long and the two pieces of paraweb temporarily secured together with a steel s-clamp.so that they do not become detached during filling operations.

3.6 Laying of filter media

i. 600mm wide filter media portion shall be filled with well-graded aggregate of size ranging between 19.1 mm – 9.5mm.
ii. The portion of filter media shall be compacted with 100 kg plate vibrator /vibro tamper.
iii. The filter media of well graded aggregate shall have a perforated PVC/HDPE pipe at the toe wrapped with non-woven geo-textiles for drainage.

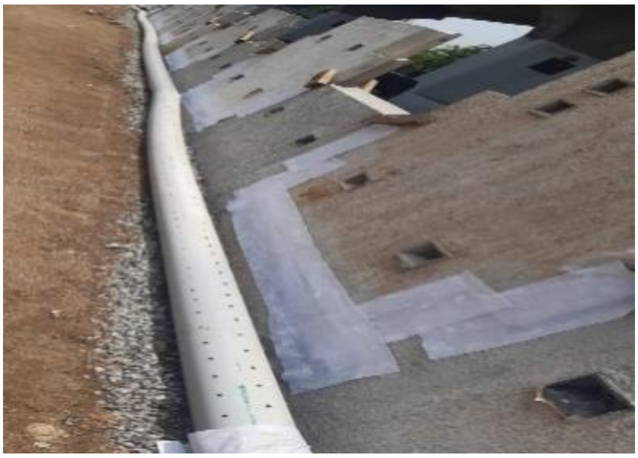

Figure 3.5: PVC pipe

iv. The pipe sections shall be joint with subsequent length by using couplers.
v. The drain pipe shall be laid at a longitudinal slope of 1in200 having outlets by using T-junctions couplers at every 50m

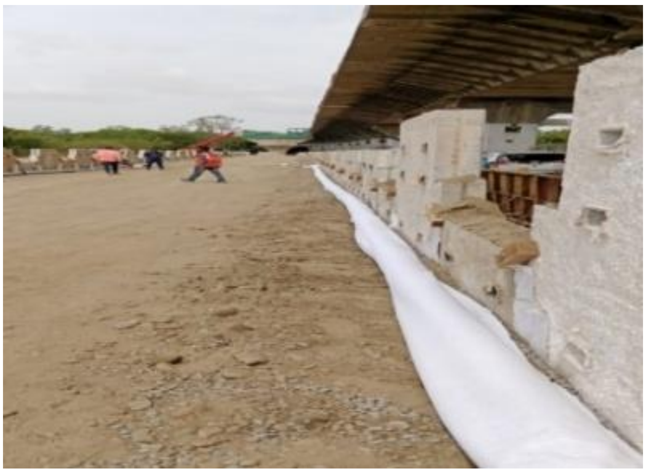

Figure 3.6: Non – Woven geo Textile

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3.7 Coping beam

- The top of the top most panel shall vary in height by 200 mm each.
- The stepped portions on top panels shall be covered with M-25 grade concrete R.C.C. coping beam.
- Coping beam thickness varies from 75mm minimum to 275mm maximum

Figure 3.7: Coping Beam

3.8 Friction slab

- It acts as a counter weight for concrete crash barrier to resist sliding and overturning.
- Here we are using M-40 grade for concreting.

Figure 3.8: Friction slab

3.9 Crash barrier

Crash barriers are design to restrain vehicles from crashing off of the side of a bridge and falling on to the road way.

3.10 Granular sub base (GSB)

- It’s also called as filter layer.
- It prevents dust particles goes base layer.
- The thickness of the GSB layer about 250mm.
- Here GRADE 5 GSB layer of mix MDD 2.355 gm/cc with OMC of 6.31% is used.Minimum 98% of MDD is achieved during compaction.

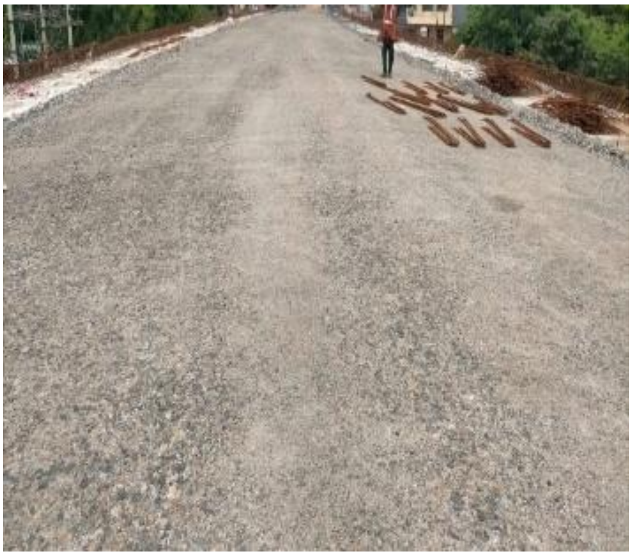

Figure 3.9: Sub base

3.11 Wet mix macadam (WMM)

- It’s also called as drainage layer.
- It drains the percolated water coming from base layer.
- The thickness of the WMM layer is about 250mm.
- Here WMM layer of MDD 2.381 gm/cc with OMC of 6.1% is used.
- Minimum 100% of MDD is achieved during compaction.
- Prime coat of bitumen emulsion SS1 grade with rate of spray of 0.7-1.0kg/sq.m is applied before laying of WMM.

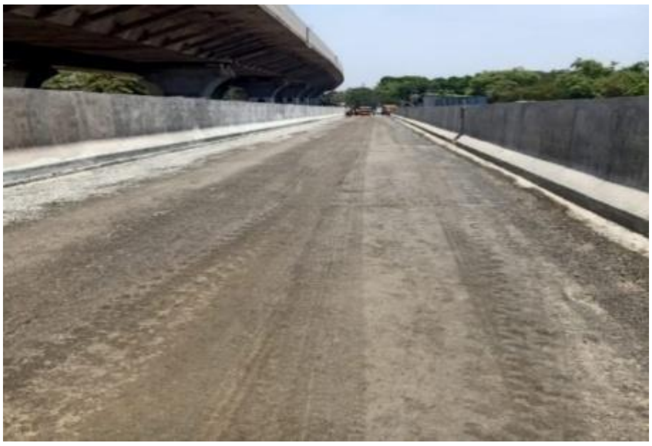

Figure 3.10: Wet Mix Macadam

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3.12 DBM – Dense Bituminous Macadam

- DBM of grade 1 mix using VG 30 Bitumen is used.
- The mix shall be laid hot at the laying temperature of 140°c (min).
- Rolling operation shall be completed in all respects before the temperature of the mix falls below 90°c.
- The compacted core shall have a field density of 2.371gm/cc (min).
- Tack coat t of bitumen emulsion RS1 grade with rate of spray of 0.20-0.30 kg/sq.m is applied before laying of DBM.

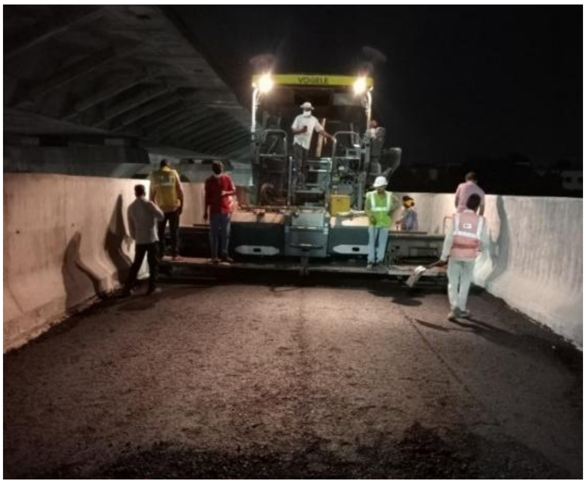

Figure 3.11: Dense bituminous macadam

3.13 BC – Bituminous Concrete

- BC of grade 2 mix using VG 30 Bitumen is used.
- The mix shall be laid hot at the laying temperature of 140°c (min).

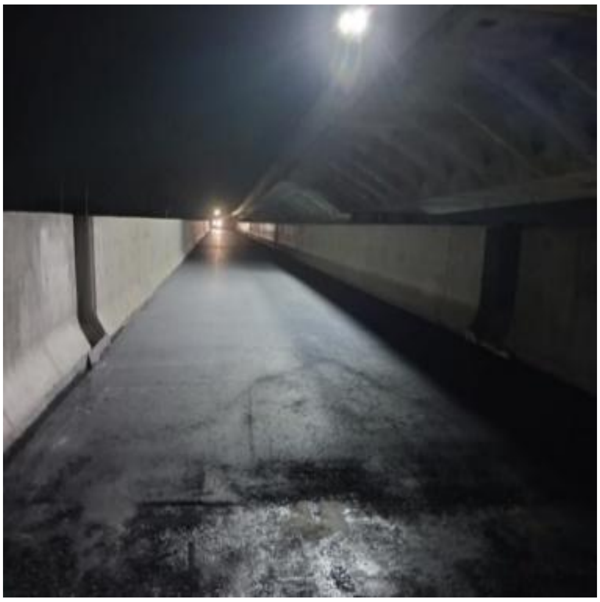

Figure 3.12: Bituminous concrete

- Rolling operation shall be completed in all respects before the temperature of the mix falls below 90°c.
- The compacted core shall have a field density of 2.333 gm/cc (min).
- Tack coat t of bitumen emulsion RS1 grade with rate of spray of 0.20-0.30 kg/sq.m is applied before laying of BC.

IV. RESULTS AND DISCUSSIONS

Earth retaining walls are a modern, reliable, and environmentally friendly solution to managing soil pressure and stabilizing slopes. They offer a combination of strength, flexibility, and durability, making them an excellent choice for a wide range of civil engineering applications.

V. CONCLUSION

Earth retaining walls constructed using a high-strength geogrid material, provide a reliable and efficient solution for stabilizing slopes and retaining earth in various applications. woven synthetic materials such as polyester or polypropylene, which offer significant tensile strength. When used in retaining walls, serves as a reinforcement that helps to resist lateral soil pressure, prevent erosion, and maintain stability, especially in areas prone to landslides or soil shifting. The installation process involves laying in layers, with each layer reinforced and backfilled with soil to ensure stability and long-term performance.

These walls are often employed in civil engineering projects, such as highway embankments, landscape terraces, and slope stabilization, due to their flexibility, cost-effectiveness, and ability to adapt to varying site conditions.

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