

# Assessment of Geogrids for Soil Reinforcement in RE Wall Applications

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## ABSTRACT

The Reinforced Earth (RE) walls have become known as an efficient and cost effective solution for earth retaining structures in various transportation and infrastructure projects. Geosynthetic Geogrid are one of the significant reinforcement materials used in RE wall systems due to their high strength, flexibility, durability and excellent soil reinforcement interaction characteristics. This study reviews the application of geogrid reinforcement in RE walls and the findings indicate that geogrid reinforced walls provide improved settlement behavior, enhanced stability and reduced lateral earth pressure compared to conventional retaining systems.

**Keywords:** Geotextile, Geosynthetics, Retaining wall, Reinforcement material

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## INTRODUCTION - REINFORCED EARTH

In case of soil which is not confined, on application of some compression stress the soil gets strained and it undergoes stress in the other direction. As shown in Figure 1, On placement of a reinforcement layer, the tensile strength is mobilized and also, the frictional force that is mobilized along surfaces of reinforcement layer leads to the confinement of the soil and thus the soil assembly exhibits higher strength. Thus in absence of the internal reinforcement there would be a need of a stiff structure outside the reinforced soil so as to provide some lateral confinement [1].

The soil with reinforcement is termed as the reinforced soil. Earlier the materials like tree branches, reeds, straw, roots of vegetations, bamboos and tree trunks were used as reinforcement and now steel, natural material and polymeric materials are used as reinforcement material. The soil being strong in compression and reinforcement in tension the combined product has much better engineering properties [1].

### Geosynthetics

Geosynthetics is the term that can be defined by breaking the term into two parts that is "geo" and "synthetics" where "geo" is related to geotechnical engineering and also geotechnical materials namely sand, soil, earth and rock. The term "synthetics" is utilized when the material is mostly produced from synthetic products. The various geosynthetic product form which are most commonly used in roadway systems are geotextiles (nonwoven and woven), geogrid

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fabric (uniaxial, biaxial and multiaxial), geocells, geonets, geomembranes and geocomposites [2].

### Geosynthetics and Reinforced Earth wall

The Reinforced Earth wall structures are cost effective solutions where inclusions of reinforcements in soil is done. Metallic strips and geosynthetics are used as reinforcements. The conventional rigid retaining structures as shown in Figure 2, made up of masonry and concrete are available that resists the lateral pressures but these traditional concrete and masonry gravity walls or cantilever retaining walls have now become obsolete due to higher cost of construction [3].

The metallic strips in RE wall have the following disadvantages :

- Higher Cost
- Long term susceptibility to the corrosion. The protective coating can reduce corrosion but it is uncertain in the

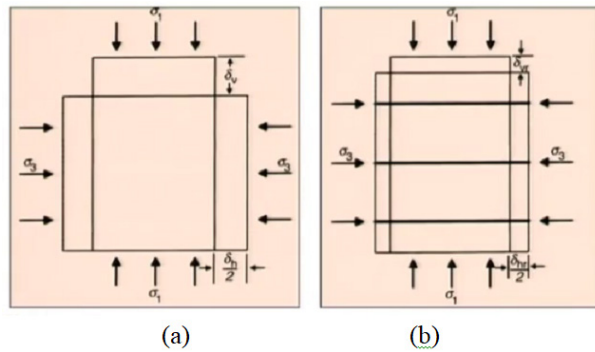


Figure 1: The basic principle of reinforced soil, (a) without reinforcement and (b) with reinforcement [1]

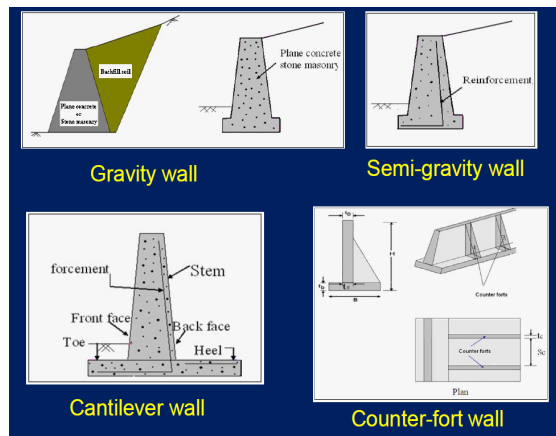


Figure 2: Different types of conventional rigid retaining structures made up of masonry and concrete available to resist the lateral pressures [3]

- field due to the ground water or electric current
- The sustainability depends on the correct choice of backfill material
- It cannot be used with many of the indigenous materials
- The back fill material cost is about 85% of total cost of the Reinforced Earth wall and the advantages of the use of geosynthetics in RE wall is as follows :
- Polymer does not corrode
- It is economical
- It can be used with many indigenous materials
- It is more deformable than metal reinforcement
- It has long term durability
- The geosynthetic material is flexible in nature
- The unskilled labour can place it
- Minimum excavation required
- Good drainage property
- Heavy equipment is not required

Geosynthetics is thus becoming an emerging engineering construction material around the world due to the advantages it has over metallic strips in RE wall. The geosynthetic material is placed horizontally in the RE wall backfill. The geosynthetic reinforced soil mass structures are basically the gravity

structures that resist the earth pressure that is developed behind the reinforced soil zone. These resist the mass of reinforced soil, retained soil and the surcharge loads. These structures can tolerate larger settlements and earthquake loading than the conventional retaining walls [3].

Geosynthetics are effectively used for reinforcement in construction of embankments and retaining walls in soft soil to attain an erect side slope and also leading to construction cost to be efficient. More importantly, in the urban areas, the project can be made cost efficient by reducing the coverage of the land on the both sides of the embankments [4].

## Reinforced Earth wall with the Reinforcement Material

In case of Reinforced Earth wall as shown in Figure 3, the reinforced soil is the combination of soil and the horizontal layers of geotextiles or geogrid fabric wherein the vertical spacing of reinforcements is kept between 0.3 m to 0.5 m. The geogrid fabrics are connected with modular blocks either mechanically or by friction and the minimum aperture size of geogrid fabric is kept 3.5 times higher than the particle size of the backfill soil. It is observed in Figure 4, that the resistance against pullout depends on friction coefficient at block joint and any engagement technique that is employed for example pins through geogrid interstices, folding geogrids over a lip in the block [3].

In the Figure 5 there is a steep slope with a face inclined at an angle in a dry cohesionless soil to the horizontal, where this angle is greater than the internal angle of shearing resistance. The inclusion of a suitable soil reinforcement would lead to the slope being safe which would not have been the case in absence of reinforcement as it would have been collapsed.

The slope consist two distinct zones which are the resistant zone and the active zone. In absence of reinforcement the active zone tends to move outwards and downwards being unstable as compared to the resistant zone. Thus if soil reinforcement is installed across the active and resistant zones it would lead to stabilization in the active zone.

The total length of the reinforcement shouldn't be limited to  $L_{aj}$  as in that case the transfer of load from soil to reinforcement in the active zone would not prevent collapse of the active zone. Thus the reinforcement extends a length  $L_{ej}$  into the resistant zone. The tensile strength of the reinforcement should be sufficient enough to sustain the tensile loads absorbed from the active zone and shed into the soil in the resistant zone [6].

In case of the active zone the load is transferred from reinforcement to soil by the mechanism of soil/reinforcement bond. The tensile load in the reinforcement over the length  $L_{ej}$  decreases towards the free end of the length  $L_{ej}$  remote from the slope face as load is shed into the soil and at the free end of the reinforcement in the resistant zone the tensile load in reinforcement is zero. Thus the flexible reinforcements are incorporated in filling during the construction and the layers of reinforcement are generally horizontal.

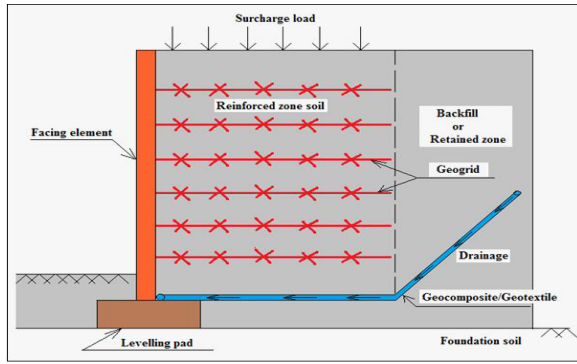


Figure 3: The components of geosynthetic Reinforced Earth wall [3]



Figure 4: Mechanical connection (pin through) and Frictional connection (lip of block) of geogrid fabric with modular blocks [5]

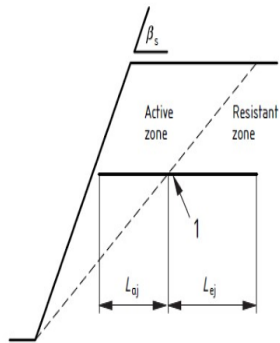


Figure 5: The reinforcing mechanism in walls and slopes

The proper designing of the retaining wall is dependent on several factors like the type and amount of wall movement, the shear strength parameters of the soil, the unit weight of the soil and the drainage conditions in the backfill.

The wall may be restrained from moving Figure 6, as in (a) then the lateral earth pressure on the wall at any depth is called the at-rest earth pressure. The wall may tilt away from the soil that is retained as in (b). With the sufficient wall tilt a triangular soil wedge behind the wall will fail and the

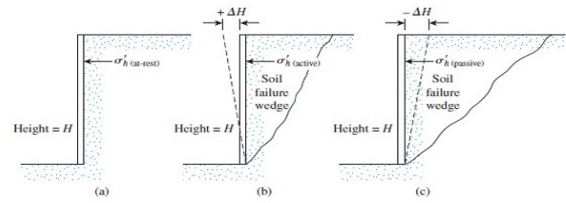


Figure 6: The lateral earth pressure on a retaining wall



Figure 7: Geogrid fabric reinforced steep slopes [7]



Figure 8: Bridge abutment with gabion facing [7]

lateral pressure for this condition is referred to as active earth pressure. The wall may be pushed into the soil that is retained as shown (c). With the sufficient wall movement a soil wedge will fail and the lateral pressure for this condition is referred to as passive earth pressure [6]. Thus, these factors need to be taken into consideration while designing the retaining wall for successful functioning, long life and stability of the Reinforced Earth wall.

The use of geogrid fabric in Reinforced Earth wall and steep slopes Figure 7, is one of the classical applications of geogrid fabrics. The bearing resistance of the geogrid fabric reinforced constructions is found to be much higher than the calculated and observed deformations are much lower than expected [7].

The geogrid fabric reinforced walls can be connected to wide variety of facing elements and they can be used for the construction of bridge abutments. Figure 8 for example shows such a bridge abutment with gabions as the facing element [7].



Geosynthetic Geogrid reinforced earth walls thus offer a technically sound and environmentally sustainable solution for the infrastructure development.

## CONCLUSION

Geosynthetic Reinforced Retaining wall play a vital role in creating an economical, safe and sustainable system. It improves the overall stability of earth structures. The infrastructure development as continues to grow, geosynthetics will remain an essential component in modern geotechnical projects. The continued research focusing on long term durability, innovative textile based reinforcement systems and field performance assessment will contribute to the optimization of geogrid technology in future civil engineering applications.

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