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# Experimental Study of The Behavior of Geosynthetic Reinforced Soil Abutments Under The Effect of Loading Shape

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**Abstract**

Using the reinforced soil method as a method to overcome the weak tensile strength of the soil with the help of metal or polymeric components with appropriate tensile strength is known as one of the fast and economical methods of stabilizing the slopes and building retaining walls. In this research, using physical modeling with high acceleration in a centrifuge, the behavior of reinforced soil abutments with a relatively high height under the effect of external overhead was evaluated. For this purpose, a reinforced soil slope with a height of 35 cm, equivalent to 1050 cm, was made in reality with a scale of 1:30 using a centrifuge and was subjected to loading at an acceleration of 30g. In the construction of reinforced soil walls, sandy soil and 6 layers of geosynthetic reinforcement with a thickness of 0.25 cm were used. The obtained results showed that the bearing capacity of foundations placed on reinforced soil abutments has a direct relationship with the shape of the foundation, and for foundations with the same width, the more the shape of the foundation changes from square to rectangular (the length of the foundation increases), the greater the bearing capacity**.** The final will be reduced. By examining soil reinforcement elements in different layers in terms of rupture and length increase, it was found that the rupture and increase is the highest for strip foundation and the lowest for square foundation. In other words, with an increase in the depth of the loading level, the impact of stress will increase and more reinforcing layers in depth will be affected by the loading.

**Keywords:** Bridge Abutment, Reinforced Soil, Geosynthetics, Physical Modeling.

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**Introduction**

One of the ways to improve soil strength is adding tensile elements (soil reinforcement) to improve its tensile strength. The invention of modern methods of reinforced soil by the French architect Henri Vidal in the early 1963s was the starting point for the invention of various other methods. Vidal named this new material as reinforced soil. Vidal was able to develop the reinforced soil method to a stage where it can be economically used in large engineering structures[1].

Geosynthetics Reinforced Soil which are used as retaining walls or bridge abutment in the construction of bridges, this type of wall works by gravity and by the friction function between the reinforcements that are placed between the soil layers, it increases the shear strength in soil. Although steel strip were first used for soil reinforcement, nowadays due to the availability of materials and polymeric fabrics known as geosynthetics, their use in soil reinforcement has become more popular. Reinforced soil walls have technical and cost advantages over reinforced concrete retaining structures in areas with poor foundation conditions. In this situation, eliminating the necessary costs for improving the foundations, such as the use of piles, will save more than 50% of the total project cost. Also, one of the biggest advantages of reinforced soil is the flexibility of these walls and their ability to decrease deformations due to the poor soil conditions of the foundations[2]. The review of the laboratory research conducted so far on reinforced soil walls shows that despite the increasing use of geosynthetic reinforcements in the construction of tall reinforced soil with high height in the last two decades, researchers have mainly studied the behavior of reinforced soil structures in the centrifuge have been investigated under the effect of the weight of the structure [3, 4]. By reviewing and investigation the previous research on the topic of this research, the gap in the behavior of reinforced soil abutments under the effect of overburden can be clearly understood[5]. Therefore, in this research, by modeling a reinforced soil wall with a height of 35 cm with six reinforcing layers in a centrifuge, which is equivalent to a wall with a height of 1050 cm in reality, the behavior of the soil wall reinforced with geotextile under external load was evaluated.

**Methodology**

Using a centrifuge device, the built model is placed in a gravity field higher than the natural acceleration of the earth. This increases the stresses caused by the weight to the extent of the real stresses, and therefore the behavior of the model is very similar to the real behavior. The centrifuge consists of a spin motor, a spin arm, and a basket containing a physical model. The centrifuge used in this research is the Actidyn C67 model, made in France and located in the University of Tehran, which has a radius of 3 meters and the area of the[4] basket where the physical model is installed has an area of 100 x 80 square centimeters. This device is able to accelerate the model weighing 1500 kg to 100 g.

A linear scale exists between the equivalent stresses in reality compared to the centrifuge model. In the construction of the centrifuge model, the dimensions are modeled with a factor of 1/N, and the gravitational volumetric forces are increased by the N factor, and the stresses caused by the similar volumetric forces in the model and the real sample will be equal. Other scale relationships should also be calculated based on these coefficients.

The material used in this research is granular soil of sand type. That sand is broken silica sand with uniform grain size.

In the construction of reinforced soil bridge abutments, generally from two groups of reinforcing materials; a) polymer materials, from the geosynthetics family and b) metal materials including steel strips are used. The increase in useful life, the economic justification and the luck of designers to use polymer reinforcements, has led to the increase in the use of this type of reinforcements.

In order to reach the height calculated for the construction of the reinforced bridge abutment model, the density of the soil was controlled by volume-weight. Therefore, first, the foundation of the model was built with a height of 50 mm using sand, then a part of the reinforcing layer with dimensions of 40 x 30 cm was spread on a part of the surface of the model, and weighted earth materials were spread on it, and The soil was pounded to the desired height, which is the calculated density. In order to reach the desired density in each test, the soil must be poured in layers. That is, in a certain volume, a certain weight of soil should be poured and pounded uniformly.

In order to increase the accuracy in reaching the target density, the layers were considered to be 2.5 cm deep. Using dry rain by funnel, keeping the height of the sand falling in each layer constant, the soil was poured and after leveling and leveling the surface, the layer was pounded using a standard laboratory hammer to reach the calculated volume. After preparing each 5 cm layer and spreading the geotextile, colored sand was used in the transparent wall of the test box to observe the changes in the condition of the soil under the foundation. In general, in order to build a reinforced earth wall using geotextile, according to the instructions of the US Army, it was done in a roundabout way[6].

A rod connected to a control hydraulic jack was used to apply an incremental static load to the model. The existing loading system is designed in such a way that it has the ability to produce a pressure force of up to 5 tons and also occupies a small space. When the basket containing the built model rotates and the stresses in the soil reach the real limit of the stresses in real conditions (equivalent to 30 times the acceleration of the earth's gravity), the rod connected to the hydraulic jack applies the force.

Two types of square foundation and rectangular foundation with the same steel material have been used in this research. The selected widths are based on the limitation of the dimensions of the centrifuge basket and the test box in such a way that the range of the impact of the wedge breaking of the foundations is not affected by the boundaries. In this research, the tests are obtained by combining the two main parameters of footing dimensions and footing distance with fixed parameters of the vertical distance of the reinforcements, the type of reinforcements, the height of the wall and the angle of inclination with the horizon.

## Findings

The measurement characteristics and the place of breakage of the reinforcements show that the breakage happened in the upper layer (sixth layer) and with the decrease in the height of the reinforced soil wall, less force was gradually transferred to the reinforcements. The lower layers (the fifth to the second layer) were only stretched, and the lower layer (the first layer) remained unchanged.

The observations of the rupture of the reinforcements after loading the rectangular foundation show that the rupture started from the upper layers (sixth to fourth layer) and with the decrease of the height of the wall in the lower parts (third and second layers) the layers were simply stretched. Also, the lowest layer (the first layer) remains unchanged.

## Conclusion

The effect of the loading shape on the final horizontal displacements of the top of the wall screed has been investigated. These displacements are recorded in the last stage of loading. As can be seen, with the constant distance of the load from the edge of the gable, the horizontal displacements on average have the highest value for the rectangular foundation and the lowest value for the square foundation. As can be seen, the largest horizontal displacement occurred in the middle two-thirds of the bridge's height.

- The bearing capacity of foundations placed on reinforced soil abutments is directly related to the shape of the foundation, and for foundations with the same width, the more the shape of the foundation changes from square to strip shape (the length of the foundation increases), the final bearing capacity will decrease.
- The types of settlement load diagrams in different foundations show that the type of failure changes from general to punch failure with the change of the shape of the foundation from rectangular to square.

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