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Evaluation of the Performance of Geo Scrap Tire Reinforcement with Horizontal Transverse Members by Large-Scale Pullout Test

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ABSTRACT: In this paper, the performance of the strip of scrap tires (Geo Scrap Tire(GST)) with horizontal transverse members evaluates as reinforcement elements in mechanically stabilized earth walls (MSEWs) by a large scale pullout test (i.e. 1.4 m × 0.8 m × 0.8 m). In this regard, the experimental pullout results of GST reinforcement compared with theoretical equations and conventional reinforcement of Geosynthetic Strip (GS), Steel Strip (ST), and Steel Strip with Rib (STR). The experimental pullout results showed that the innovative suggested reinforcement element performed better than the other strips so that the GST strip was capable of increasing pullout resistance by more than 3, 2.5, and 1.5 times compared to the steel strip, the geosynthetic strip, and the ribbed steel strip. The results show maximum pullout resistance of GST affected by the S/B ratio and adding three horizontal transverse members can be increasing pullout resistance by more than 5.9, 4.9, and 3.2 times compared to ST, GS, and STR. Thus, using GST reinforcement with three horizontal transverse members needs a smaller length (less than 30%) comparing to conventional strip reinforcement (ST, GS, STR). Therefore, using Geo Scrap Tire reinforcement can open a new horizon in solving the problem of scrap tires and assure geotechnical engineers in achieving superior and more economical systems of reinforced soil walls.

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1- Introduction

Recently Mechanically stabilized earth walls (MSEWs) turn into the popular option of implementation of walls around the world. Various experimental research has shown the excellent performance of the reinforced earth retaining walls [1-3]. Investigation bout factors that influence pullout resistance between soil and reinforcement elements will lead to a better understanding of the behavior of reinforced earth retaining walls. The pullout test has been commonly used for evaluating the behavior of soil and reinforcement. Moreover, different parameters that are affecting the results of pullout resistance of reinforcement were investigated with the various author [4-7]. Annually millions of scrap tires are generated around the world, and the accumulation of scrap tires causes pollution of the environment and air. The numerous scrap tires released in nature are a serious threat to human health. The solution of disposal of scrap tires turns into one of the interesting issues for researchers. Today, three main methods are used to solve the problem of scrap tires: material reuse, fuel derivation, and civil activities. The first approach includes grinding scrap tires and used in surfaces of athletic tracks or games, or combined with other materials such as asphalt [8], Concrete [9], rubber and thermoplastic matrices [10], and epoxy resins [11]. This study proposed to utilize waste tire strips as reinforcement elements in reinforced earth retaining walls. For achieving this purpose used one truck scrap tire (385/80/R22.5) and separated two side walls. In the next step, the embossed side of the scrap tire is extracted from the strip of a tire and divided into elements with the desired dimension and use as transverse members. The residual strip the tire is divided into strips with a width of 70 mm and use as a reinforcement element, which is called Geo Scrap Tire (GST). To examine the performance of the Geo Scrap Tire with the horizontal transverse members (GSTn) used large-scale pullout tests (i.e. 1.4 m × 0.8 m × 0.8 m). In this regard, for evaluating the efficiency of the GSTn in compared conventional strip reinforcement, used steel strip, geosynthetic strip, and steel with rib on top.

2- Methodology

In this study, the pullout test box with dimensions of 1.40 m length, 0.8 m width, and 0.8 m height (1.4 m × 0.8 m × 0.8 m), manufactured based on ASTM D6706. The horizontal and vertical force applied by a hydraulic force actuator device with a maximum capacity of 120 kN and pneumatic airbag with a capacity of 150 kPa, respectively. LVDT and load cell with a capacity of 150 mm and100 kN have been used to measure the displacement and force. In this paper, for minimizing the effect of a frontal wall of the box used two

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sleeves with 200 mm width and 10 mm thickness and based on the Suggestion of ASTM D6706 (If the reinforcement is at least 150 mm space from each sidewall) disregard frictional resistance of sidewalls of the box. To carry out tests, the soil layer below the reinforcement was placed in four layers of roughly 90 mm thickness.

3- Discussion and Results

Among different reinforcement, the displacement required to reach the peak force in the GST strip is highest, and for different normal stresses, this value is almost constant (18-22mm). The amount of displacement for the STR strip in different normal stresses was 14-16 mm. The displacement for reached maximum pullout resistance for GS and STR higher than other reinforcement because the GS and STR have a rib on top or bottom surface. In the steel strip reinforcement because of the smooth surface, the displacement required to reach the maximum force is the lowest (3-4 mm).

For GST and GST1, the increment of pullout resistance while reaching peak force is high and then gradually decreases. The granularity of the soil and overcoming to interlocking between different particles of dense sand caused the pullout force reached to the maximum, and after a peak in more displacement, soil failure occurs, and the pullout resistance decreases (strain-softening behavior). The adding of one transverse member increased the pullout resistance. This result due to the changed behavior of pullout resistance from frictional to frictional-passive. The displacement required for reached full mobilization of pullout force in GST is between 18-22 mm, and for GST1, the maximum pullout force obtained is higher displacement than GST. This result is due to the geometry of transverse member and resistance of soil in behind and front of transverse member. Predict of bearing resistance of reinforcement is one of the interesting problems that different authors research about it. Various equations and mechanisms are proposed to evaluate bearing resistance. The main bearing failure mechanisms are as follows:

- The general shear failure mechanism [12].
- The punching failure mechanism [13].
- The modified punching failure mechanism [14].

For normal stress of 25 kPa, the experimental results closer to values predicted by the modified punching shear failure mechanism. For higher normal stress (50-75 kPa), the punching shear failure mechanism concurs well with the large-scale pullout test results.

In the implementation of some of the MSEW, because of the limitation of space constraints, there is no possibility of increasing reinforcement length. In this condition increase of pullout resistance with adding of the transverse member can be one of the best options.

The highest increase in pullout resistance compared to GST for all normal stress (for normal stress of 25, 50, and 75 kPa were 92.4, 90.1, and 98.5%, respectively) have been obtained for GST3. For GST with more than three transverse members (n >3) despite an increase of transverse members, the pullout force has decreased, and this result is due to the interference of various transverse members together.

4- Conclusions

This paper investigates the performance of newly suggested reinforcement of Geo Scrap Tire with a horizontal transverse member by large-scale pullout tests (i.e.1.40 m × 0.8 m × 0.8 m). The pullout resistance of GSTn evaluated under different normal stresses (25, 50, 75 kPa) and compared with conventional (GS, ST, and STR) reinforcement. The maximum pullout resistance of GST1 is predicted by the proposed theoretical analysis and compared with large-scale pullout test results. The pullout resistance of GST1 reinforcement is the sum of friction resistance and passive resistance, and due to change in the behavior of pullout resistance from frictional to frictional-passive, the displacement required for reached full mobilization of pullout force in GST1 is higher displacement than GST. Adding the transverse member is one of the best options for MSEW, that existing limitation of space constraints. The highest increase in pullout resistance compared to GST for all normal stresses (for normal stress of 25, 50, and 75 were 92.4, 90.1, and 98.5%, respectively) have been obtained for GST3.

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