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Laboratory Investigation of the Effect of the Cement Treatment of the Interface and the Thicknesses of Reinforcement on its Pull-out Capacity

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ABSTRACT: Mechanical specification of the interface of soil and reinforcement is one of the most important parameters of the design and construction of reinforced soil systems. Anchorage length of the reinforcement is determined based on the soil-reinforcement interface parameters. Required long anchorage lengths restricts the application of reinforced soil systems. Improving the mechanical parameters of the soil-reinforcement interface could be used to develop the applications of reinforced soil structures in projects with limited space. In this research, the cement treatment of the interface of the soil and reinforcement was employed to improve the pull-out capacity of the reinforcement and consequently to reduce the anchorage length. The effect of the cement treatment on the pull-out capacity of the reinforcement was studied in the laboratory. Also, the effect of the increased thicknesses of the reinforcements resulted from the cemented layers adhered to the reinforcement surface was investigated. The laboratory tests conducted using specially developed pull-out test device. The tests conducted on high-strengths woven geotextiles with different thicknesses with both pristine and cement treated interfaces. Cement treatment carried out with 1.5 g/cm^2 portland cement sprayed on water saturated geotextile. The results of tests conducted on pristine reinforcements with different thicknesses showed that increasing the thicknesses of the reinforcements increase the pull-out capacity. Also, the cement treatment increases the pull-out capacity of reinforcements. The results of this study show that cement treatment of the interface of soil and reinforcement increases the pull-out capacity of the reinforcement in two different mechanisms by increasing the thicknesses of the reinforcement and creating a rough surface on the reinforcement with higher interface friction angle.

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1. INTRODUCTION

Soil is the most prevalent material used in the construction projects. All superstructures are constructed on the soil that is the final load bearing element. Since it is a granular material, its strength is provided by the frictional loads interacting at the interfaces of its solid particles that could be improved by increasing the confining forces. Soils in their natural state have a limited amount of shear strength and neglectable tensile strength [1]. There are several methods categorized in two main mechanical and chemical methods to improve the shear strength of the soil. Inclusion of geosynthetics within a soil mass is a mechanical stabilization method that is used to improve the mechanical properties of soil. Reinforcement elements are usually in the form of geosynthetic sheets or steel strips [1]. Stability of the reinforced soil systems are controlled by three parameters namely; tensile failure of reinforcement elements, shearing failure of soils mass and relative slippage at the interface of soil and reinforcement in the form of pull-out failure [2]. Mechanical specification of the interface of soil and reinforcement is one of the most important parameters of the design and construction of reinforced soil systems. Anchorage length of the reinforcement is determined based on the soil-reinforcement interface parameters. Required long anchorage lengths restricts the application of reinforced soil systems. Improving the mechanical parameters of the soil-reinforcement interface could be used to develop the applications of reinforced soil structures in projects with limited space [3]. In this research, the cement treatment of the interface of the soil and reinforcement was employed to improve the pull-out capacity of the reinforcement and consequently to reduce the anchorage length. The effect of the cement treatment on the pull-out capacity of the reinforcement was studied in the laboratory. Also, the effect of the increased thicknesses of the reinforcements resulted from the cemented layers adhered to the reinforcement surface was investigated. The laboratory tests conducted using specially developed pull-out test device. The tests conducted on high-strengths woven geotextiles with different thicknesses with both pristine and cement treated interfaces. Cement treatment carried out with 1.5 g/cm2 portland cement sprayed on water saturated geotextile.

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2. MATERIALS

Laboratory tests conducted using a specially developed geosynthetic pull-out apparatus. The loading box's dimensions

Fig. 1. Geotextile pull-out device

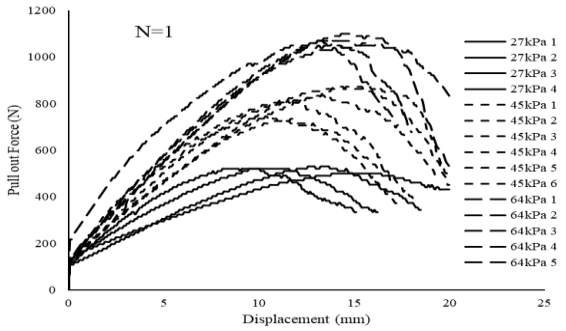

Fig. 2. Pull-out capacity of pristine reinforcement with 2 mm thicknesses

was 40 cm length 40 cm widths and 20 cm height and is shown if Fig. 1. Sand used in this study was a poorly graded sand with internal friction angle of 37 degrees and unit weight of 16.3 kN/m^3. Geosynthetic used in pull-out tests was a high-strength woven geotextile with unit weight, tensile strength, elastic modulus and elongation at failure of 450 kg/m^2, 17.5 mPa, 35 kN/m and 4.5% respectively.

3. LABORATORY TESTS

Pull-out tests conducted on reinforcement strips with dimensions of 40 cm length and 5 cm width with embedded length of 20 cm in two pristine and cement treated conditions. Cement treatment of the geosynthetic interface performed by 24 hours water soaking the reinforcement strip and spraying 0.15 gr/cm^2 portland cement and applying a layer of saturated sand on both sides of that. All the specimens cured for one week at room temperature about 25 degrees of centigrade. The test box filled by sand using raining technique from a height of 50 cm in two stages. At each stage 26 kg of sand replaced in the box and compacted to reach to the height of 10 cm. Then the reinforcement layer implemented and the second layer placed on it. All of the tests conducted in this study repeated at least three times to ensure the accuracy of the testing method.

4. RESULTS

The results of pull-out tests conducted on pristine geotextiles under three different normal stresses for 1-layer

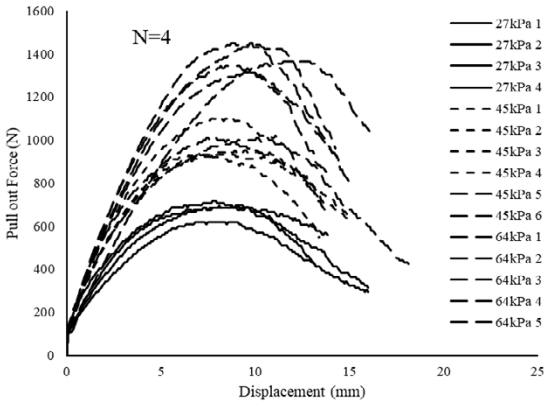

Fig. 3. Pull-out capacity of pristine reinforcement with 8 mm thicknesses

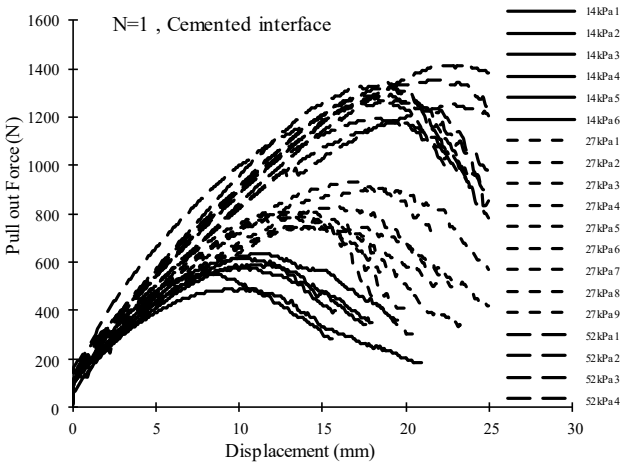

Fig. 4. Pull-out capacity of cement treated reinforcement with 6 mm thicknesses

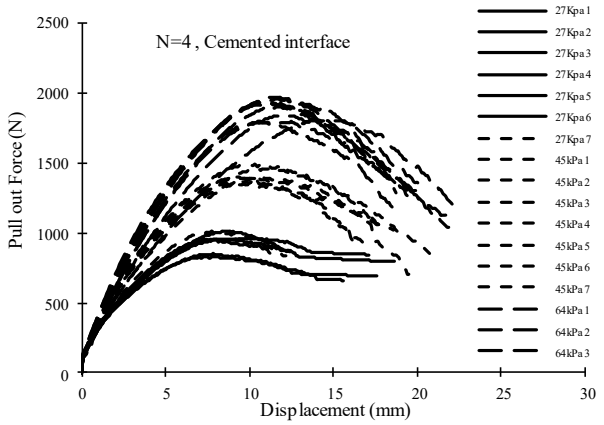

Fig. 5. Pull-out capacity of cement treated reinforcement with 12 mm thicknesses

and 4-layer reinforcement with different thicknesses are shown in Fig. 2 and Fig. 3 respectively. It should be noted that the material of both specimens was the same. The only difference was in the thicknesses of the strips. It can be seen that an increase in the thicknesses of the reinforcement increases the pull-out capacity of the reinforcement.

Increasing the thicknesses of the reinforcement from 2 mm to 8 mm increased the pull-out capacity approximately 28%. The average rate of the increment in pull-out capacity related to the thicknesses of the reinforcement was about 6.9%.

Fig. 4 and Fig. 5 shows the results of pull-out tests conducted on reinforcements with cement treated interface with 6 mm and 12 mm thicknesses respectively.

It should be noted that 6 mm thick reinforcement was composed of one-layer reinforcement with two layers of cemented layers on it and 12 mm thick reinforced was composed of 4 layers of reinforcements stitched together with two layers of cemented layers.

Comparing the results of tests conducted on pristine and cement treated reinforcements shows a 42% increase in the pull-out capacity.

5. RESULTS AND DISCUSSION

The results of the tests conducted in this study show that increasing the thicknesses of the reinforcement improves the pull-out capacity of that. Also, the cement treatment of the interface of the reinforcement and soil increase the pull-out capacity. Excluding the effect of the increased thickness resulted by cement the treatment on the pull-out capacity by comparing pristine and cement treated reinforcements with similar thicknesses shows a 22% increment in the pull-out capacity

6. CONCLUSIONS

Based on the results of this study it could be concluded that cement treatment of the interface of soil and reinforcement improves the pull-out capacity by two mechanism of creating a rough surface with larger friction angle and increasing the thicknesses of thr reinforcement.

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