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A laboratory study of the influence of reinforcement stiffness and the size of soil particles on Reinforcement pull-out

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ABSTRACT: The interaction parameters between soil and reinforcement at their interface play a critical role in influencing the mechanical behavior of reinforced soil systems. Interaction parameters between soil and reinforcement influence reinforced soil behavior mechanically. In this research, the effect of the size of soil grains and the stiffness of the reinforcement on the pull-out resistance of the reinforcement from the soil has been investigated in a laboratory. The pullout resistance of three types of reinforcements with different stiffness in three types of soil with different grain sizes has been investigated. Pull-out tests have been performed at three stress levels of 50, 100, and 150 kPa. To investigate this issue and determine an evaluation for the stiffness of the reinforcement, a device has been built to measure the penetration of solid soil grains in the reinforcement. The results of the tests show that the penetration of soil grains into the reinforcement has a significant impact on the resistance of the reinforcement to being pulled out of the soil. The amount of penetration of solid soil grains into reinforcement increases by reducing the stiffness of the reinforcement and increasing the size of the diameter of the soil grains. For each specific vertical stress level, the greater the penetration of solid soil grains into reinforcement, the higher the pull-out strength of that reinforcement. The results show that with the increase in the diameter of the solid grains of the soil, the pullout resistance of the reinforcement has also increased, but this increase has been more significant in the case of reinforcement with lower stiffness compared to reinforcement with higher stiffness. Also, the difference in the pullout resistance of three reinforcements with different stiffness in fine-grained soil was less than the difference in the pullout resistance of three reinforcements in coarse-grained soil, which indicates the simultaneous effect of reinforcement stiffness and soil grain size on pullout resistance.

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1- Introduction

An important factor in the design and analysis of reinforced soil systems is the interaction between soil and reinforcement. It is possible to improve the safety and reliability of reinforced soil systems by developing a more accurate and deeper understanding of the soil and reinforcement interaction parameters [1, 2]. Using reinforcing elements increases confining stress and, consequently, increases the soil's resistance [3-5]. There is a close relationship between the stress distribution in the soil and the placement of reinforcements in the soil. So that by changing the arrangement of reinforcement in the soil mass, the stress distribution in both horizontal and vertical directions of the mass can be changed [4]. The indentation of soil grains in reinforcement has a significant effect on the shear and pull strength of soil reinforcement. Various parameters, such as the size of the soil grains, the type of reinforcement, and their stiffness, affect the shear resistance of reinforced soils [6, 7]. One of the most important parameters of the pull-out strength of reinforcing soil is the type of deformation created in reinforcement. As a result of the change in the stress level and the size of the soil grains in reinforcement, there is a state of depression and elevation on the surface of reinforcement. As a result of creating a wavy state on the surface of the reinforcement, the conflict between the soil grains and the reinforcement increases [8]. A major objective of this study was to investigate the influence of the mechanical characteristics of reinforcement and soil on the interface characteristics. This deformation is a function of the stiffness of the reinforcement and the size of the soil grains. For this purpose, the pull-out strength of different types of reinforcement with different levels of stiffness in three types of soil with different grain sizes has been investigated

2- MATERIALS

In the laboratory, geosynthetic pull-out apparatuses were developed and tested. As shown in "Figure 1", the loading box's dimensions were 610 mm long, 460 mm wide, and 320 mm high. In this research, three types of granular soil including sand, fine and coarse gravel were used. The reinforcement consists of two types of geotextile and one

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Fig. 1. Geotextile pull-out device

type of steel strip. Geotextiles used in this study are woven. It was chosen that the reinforcements used would have varying degrees of stiffness.

3- LABORATORY TESTS

Using reinforcing strips placed 16 cm above and 16 cm below the sample layer, the reinforcing strips were in the middle of the sample layer. The dimensions of the geosynthetic tape were 15 cm (width) x 70 cm (length). 30 cm was the length of reinforcement buried within the soil mass. To ensure the accuracy of the test method, all tests conducted in this study were repeated at least three times.

4- RESULTS

The results of the pull-out test performed on reinforcement strips with high stiffness (steel reinforcement) in sandy and coarse gravel at stresses of 50, 100, and 150 kPa are shown in “Figure 2”. The average pull out force of steel reinforcement in sandy soil and coarse gravel is about 7.4 and 8.73 kN, respectively. The highest pull out force related to coarse-grained soil at vertical stress of 150 kPa is 11.88. The results of the tests performed with type 2 and 3 geosynthetic reinforcement at stresses of 50, 100, and 150 kPa respectively in sand and coarse gravel are shown in Figures “Figure 3” and “Figure 4”. The highest pull out force obtained from type 3 geosynthetic reinforcement was 16.2 kN from coarse soil corresponding to 150 kilopascals of vertical stress. By comparing the results of the Figures, it can be seen that the pull out strength increases significantly with the reduction of reinforcement stiffness. So that by reducing the stiffness of reinforcement in sandy soil from metal reinforcement to type 3 geosynthetics, the pull out strength increased by about 36%.

5- Conclusion

According to the results of the tests conducted in this study, in addition to the mechanical characteristics of the soil and the shear strength parameters, the stiffness of the reinforcements and the sizes of the soil particles also play a significant role in determining the shear resistance of the interface and the resistance of reinforcements to pull out of the soil during shear. By reducing soil penetration in reinforcement, the external elongation resistance is reduced. For each reinforcement, with the increase in the diameter of the soil grains, the pullout resistance and the interaction coefficient between the reinforcement and the soil have increased.

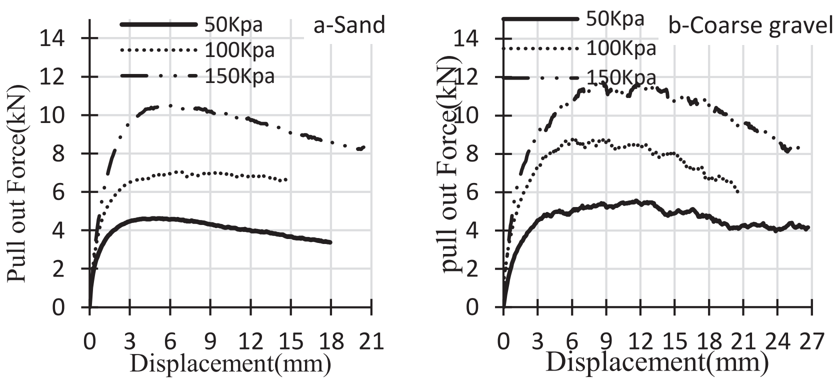

Fig. 2. Pull out the capacity of steel reinforcement at (a. sand b. coarse gravel)

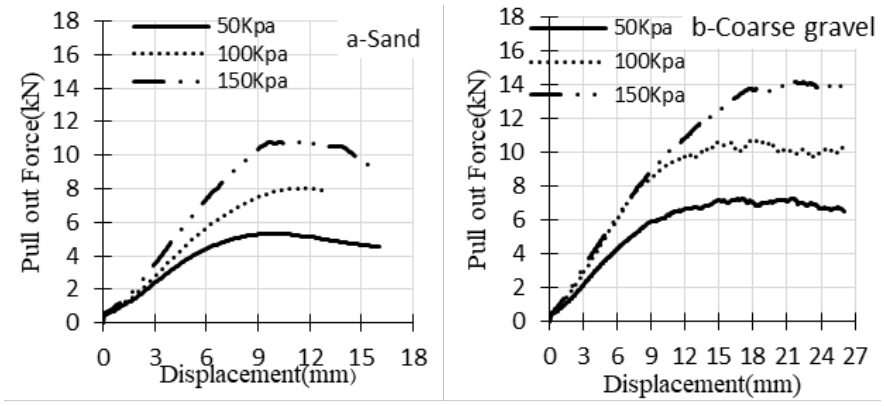

Fig. 3. Pull out the capacity of type 2 geosynthetic (Stiffer geosynthetic) reinforcement at (a. sand b. coarse gravel)

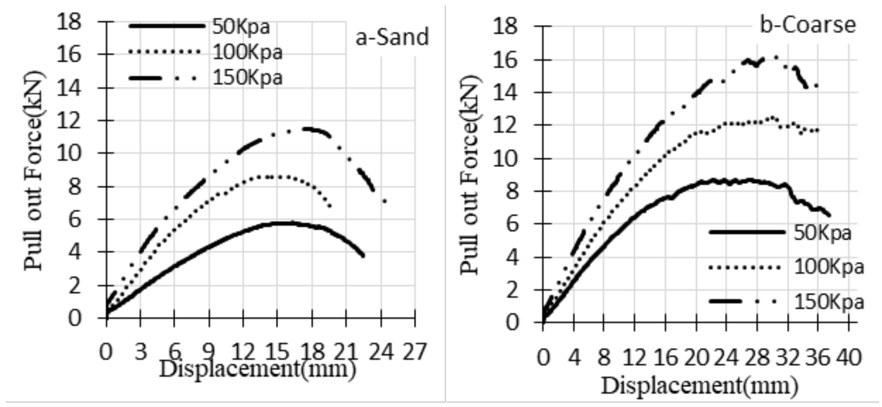

Fig. 4. Pull out the capacity of type 3 geosynthetic reinforcement at (a. sand b. coarse gravel)

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