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Comparison between the Interface Interaction of Sand and Clayey Sand with PET Geogrid in Pullout Test Based on Active Length

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ABSTRACT: Large pullout test is used to investigate the geogrid pullout behavior in the anchorage zone. When the pullout load is applied to the geogrid, this force is gradually transmitted along with the sample until it reaches the end of the geogrid. In order to more accurately investigate the soil-geogrid interaction mechanism, the pullout behavior of geogrid should be evaluated based on the active length. In this study, by performing a series of large-scale pullout tests, the distribution of shear stress and pullout interaction coefficient of a PET geogrid embedded in clean sand and 20% clayey sand were investigated based on active length. The results showed that the value of the pullout force to start the movement of the last geogrid transverse member increased with increasing vertical effective stress in both geogrid embedded in two soil. In all pullout tests, minimum active interaction coefficient was obtained at the conversion of transfer force stage to pullout stage.

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1- Introduction

One of the most important parameters for the design of the reinforced soil structures are pullout resistance and soil-geogrid interaction coefficient at the interface. For this purpose, large-scale pullout tests are usually used to determine the soi-geogrid parameters at the interface. To more accurately investigate the interaction between soil and geogrid, the active length of geogrid should be determined during pullout tests. Moraci and Recalcati [1] studied the behavior of three types of HDPE geogrids under different effective vertical stresses in sandy soil and obtained the interaction coefficient of the soi-geogrid interface in both peak and residual states based on total geogrid length. Their results indicated that peak and residual soil-geogrid interface coefficient decreases as vertical effective stress increases. Ferreira et al. [2] investigated the pullout behavior of four different types of geosynthetics including two geogrid, one geotextile and one geocomposite embedded in granite residual soil at different relative densities. They found that with increasing relative soil density, the pullout interaction coefficient based on total length decreases. Cardile et al. [3] evaluated the pullout behavior of two HDPE geogrid embedded in sandy soil at different lengths. They calculated the soil-geogrid interface coefficient as well as shear stress based on the active length of geogrid. In order to investigate the effect of fine content and geogrid stiffness on the pullout interaction coefficient, this study investigated the pullout behavior of two types of uniaxial PET geogrid with the same geometrical structure embedded in clean sand and 20% clayey sand based on active length.

2- Materials

The soil used in this study is clean sand and clayey sand. Clayey sand was prepared from a combination of uniform silica firoozkooh sand and 20% kaolinite clay, measured based on the dry weight of the sand. Pullout tests were carried out on two types of polyester uniaxial geogrid (PET) under the brand name GPGRID 80/30 (GP1) and GPGRID 110/30 (GP2). Table 2 shows the geometrical and mechanical specifications of these two types of geogrid prepared by the manufacturer.

In order to determine the physical and mechanical properties of two types of soil, laboratory tests were performed according to appropriate ASTM standards. The physical properties and shear strength parameters of clean sand and clayey sand are given in Table 1.

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Table 1. Physical and mechanical characteristics of the used soil [4]

Sand		Clay		clayey sand
USCS	SP	USCS	CL	SC
D_{50}	0.77 (mm)	LL	42 (%)	0.62 (mm)
C_u	2.14	PL	28 (%)	8.7 (%)
Cc	0.89	PI	14 (%)	20.59 (kN/m^3)
G_s	2.65	G_s	2.62	36.6°
OMC	10 (%)	OMC	23 (%)	14.83 (kPa)
γ_{dmax}	15.89 (kN/m^3)	γ_{dmax}	14.91 (kN/m^3)	
ϕ_p	39.2°	ϕ_p	10°	
C	5.57 (kPa)	C	23.2 (kPa)	

OMC: Optimum Moisture Content

Table 2. Properties of GPGRID 80/30 (GP1) and GPGRID 110/30 (GP2)

Geogrid	GPGRID80/30 (GP1)	GPGRID110/30 (GP2)
Raw material	PET	PET
Coating	PVC[1]	PVC
Ultimate longitudinal tensile Strength (T_{ult})	80 (kN/m)	110 (kN/m)
Ultimate lateral tensile Strength	30 (kN/m)	30 (kN/m)
Longitudinal strain at T_{ult}	12 (%)	12 (%)
Longitudinal tensile stiffness at 5% strain	690 (kN/m)	860 (kN/m)
Aperture size, (longitudinal)	33 (mm)	33 (mm)
Aperture size, (transverse)	25 (mm)	25 (mm)
Thickness (*B*)	2 (mm)	2 (mm)

3- Results and Discussion

The variation of the active pullout interaction coefficient versus the frontal displacement of GP1 and GP2 geogrid samples embedded in clean sand and clayey sand under vertical effective stresses of 20, 40 and 60 kPa are shown in Figure 1. Similar to the trend observed for active shear stress, the values of active pullout interaction coefficient in small frontal displacements are large and decrease with increasing frontal displacement until the pullout stage occurs. In all experiments performed on two types of geogrid embedded in two types of soil, the lowest value of the active pullout interaction coefficient was obtained at the point of conversion of the pullout stage to the pullout stage (moment of movement of the last transverse member). The pullout interaction coefficient at the end of experiments for GP1 embedded in clean sand and clayey sand and GP2 in clayey sand decreases with increasing vertical effective stress. Previous studies in the field of calculating the pullout interaction coefficient considered a constant value for this coefficient during the pullout test. However, the present study shows that the value of the pullout interaction coefficient changes with increasing the frontal displacement of geogrid and considering a constant value for it can lead to sometimes conservative,non-economic, or risky designs.

4- Conclusions

1- The value of the pullout force required to start the last transverse member of the geogrid increased with increasing the vertical effective stresses in both geogrid embedded in clean sand and clayey sand.

2- In all experiments performed on two types of geogrid embedded in clean sand and clayey sand, the lowest value of the active pullout interaction coefficient was obtained at the point of the load transfer stage to the pullout stage.

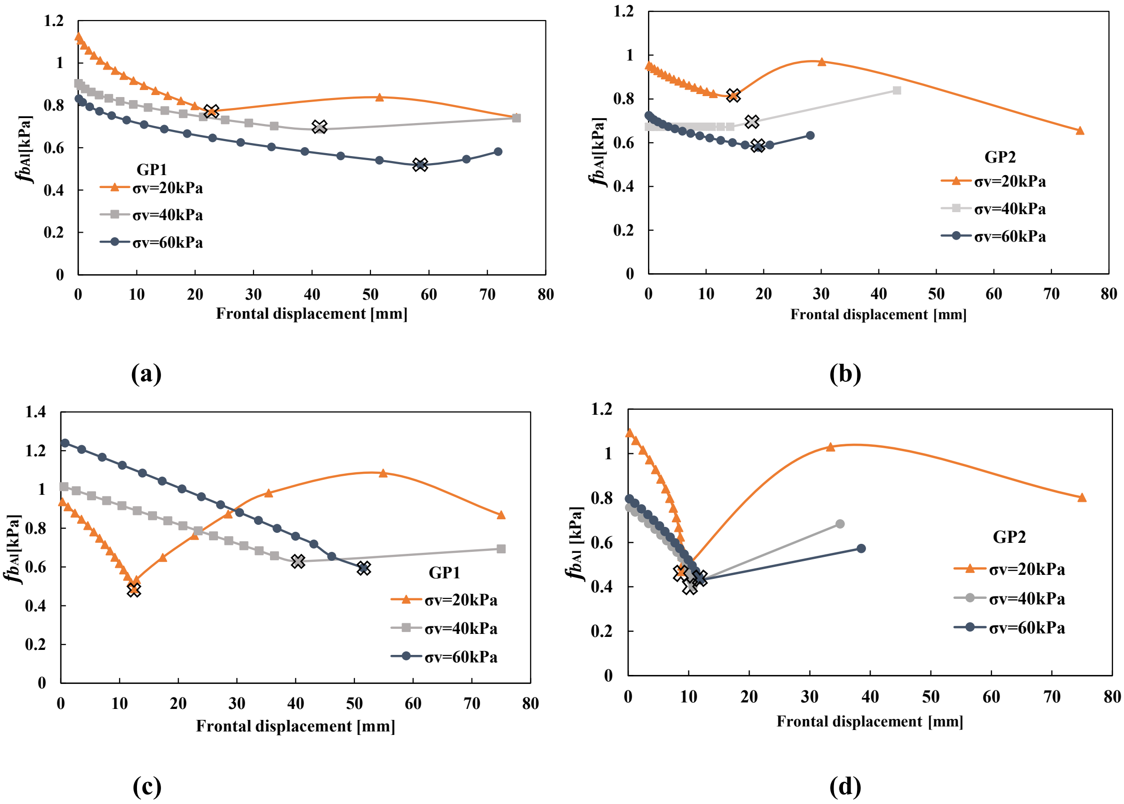

Fig. 1. The variation of pullout interaction coefficient versus frontal displacement under different vertical effective stress for a) GP1 in clean sand, b) GP2 in clean sand, c) GP1 in clayey sand, d) GP2 in clayey sand

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