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Field Study of the Effect of Drilling Type on Tensile Strength and Creep Behavior of Soil Nails in Tabriz Green Marl

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1. Introduction

One of the most important problems in civil engineering is constructing structures, protecting excavation and the building in thei r surrounding and stabilizing embankments. Non-observing proper methods for protecting deep and also constructing slopes will lead to irreparable damage and the risks resulting from probable subsidence and reducing the bearing capacity and lateral displacements will cause cracks in neighbouring structures. Using the Soil Nailing due to its numerous advantages, the traditional approach is to stabilize the excavation walls fitted. Due to the different behavior of marl soils in short and long-term and fundamental role of friction between soil cement grout around the walls were nailed. In this study, tensile strength and creep behavior of soil nails to maintain green marl are discussed. Studying the nails behavior in marl and clay soils which are considered as fine-grained soils with different properties compared to grained soils are the subjects which have been less attended to. High plastic properties, semi-Saturation state, changing its behavior in long-term, very low grouting and other similar cases are among the problems which necessitate studying the nail function in these types of soils. Regarding the diversity of marl in surface (yellow, green, olive green) it is not possible to study all of them in .a short time and it needs more time and more cost. However, this research studies the behavior of nailing systems in these types of marls due to multiplicity of olive green soil which is observable in most civil projects in the city and in lower depth of lands (see Table 1).

2.Methodology*(Material and Equipment and Test Program)*

Marl is a term for depositions which are formed by combination of Rousseau sodium carbonate. Marls are exposed in eastern, northern and southern districts of Tabriz and in most city areas. They form bedrock, in other words, they are under alluvial deposits. These marls are seen in different colors such as yellow, olive green, brown and gray. The yellow and green layers are usually put on the surface and gray marls are placed down deep and the mark soils are mechanically classified in the group of clays or silty with high plasticity. The marls' smoothness and plasticity index are in an extended area which shows the variability of carbonate calcium percent and type of clay composing marls.

Tabriz marls have a wide diversity in different areas. Such diversity is observed in their appearance and in their engineering properties and compositions. These marls show different geo-mechanical behavior in different conditions such as depth, amount of overhead, natural humidity, saturation, clay percent and also gypsum and coal lines.Considering the importance of these marls and their expansion in Tabriz and their different function, this study is done on the behavior of this type of marls against nailing system. The nails implemented in marl soil show different behavior compared to other soils due to humidity, smoothness and high plasticity which causes change in behavior of implemented structures in this kind of soil. Studying and scientific experiences show a reduction of tensile power of nails in marl soil as time pases by which can be due to creeping behavior of this type of soil and aligning the clay grains under load. Improving the nail behavior in marl soil with different methods and increasing the tensile capacity and improving its creeping behavior especially in the long-term is considered as the main aims of this paper. Using non-smooth drilling type can provide more proper conditions due to establishing proper involvement of grout with soil of the nail wall and probability of establishing displacement in the wall and section of nails and the tensile and creeping behavior of the nail will improve. It is noteworthy that regarding the types of marls with different capabilities and behaviors, the results are changeable upon changing the type of marl.

For doing tests, a device that can measure and register the force, pressure values and displacements with high precision is needed.I In this case; a nail anchoring was made which can measure the force by 50 tons and measure the deformations in 0.1-mm precision equipped with a data logger for registering the data automatically once each 6 seconds. The mentioned device is equipped with a creep lock system for fixing the force value in time and if the force is reduced for any reason, it controls the value of the force at the defined fixed value set by the device via exerting oil pressure. Pressure load cell, pressure valve, drain valve, two-way leverage for exerting pressure, USB gate for memory record, monitoring systems (force, pressure and deformation) and panel of internal settings of device with base jack, system of connecting jack to nail, and ohm marking are the main parts of the mentioned device. Considering the recommendations of FHWA standard and other valid standards for measuring the displacement with 0.01-mm precision, two gauge with the mentioned precisions were installed for measuring the nail and foundation displacements under the jack for reading data precisely in defined intervals according to the related criteria. Considering the low sensitivity in borehole drilling and repeatability of tests, the drilling systems shall have a

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high precision and quality and low and acceptable vibration. For this reason, drilling equipment were prepared which can do vertical and horizontal drilling with defined angle and 360 degree circulation, grout set with pressure exertion by 10 times, mixer of primary and secondary mixing and also special packer for grouting (Fig. 1).

Fig. 1 Images of Nail tension Jack with accessories

Table. 1 Properties of olive marl used in plan and its strength parameters

Angle of Internal Friction (Degree)	Cohesive (kg/cm²)	Plastic Limit PL (%)	Liquid Limit LL (%)	Humidity (w %)	Wet Density (kg/m³)	Depth (m)
20	1.2	50	74	38	1850	2
21	1.3	59	76	40	1900	5

Table. 2 Dimensional properties of nails and used grout

Additives	Cement Grout	Bar Size (mm)	final diameter of the Nail (cm)	Free length of the Nail (m)	Injection Along the Nail (m)
Cebex 100	II2	32	11	0.6	4

Table 3. Results of real tests, dimensional properties

Reliable force to perform(ton)	Start unacceptable creep (ton)	Maximum Pullout Resistance(ton)	Grout Type	Drilling Type	Run mode	Free length of the Nail (cm)	Injection Along the Nail (cm)	Nail Diameter(cm)	Nail number
15	19	22	Cement(Type II)+ Gravity injection	Rotary (non- smooth wall)	Vertical	60	400	11	1
16	17	21	Cement(Type II)+ Gravity injection	Rotary (non- smooth wall)	Vertical	60	400	11	2
15	18	22	Cement(Type II)+ Gravity injection	Rotary (non- smooth wall)	Vertical	60	400	11	3
12	15	18	Cement(Type II)+ Gravity injection	Rotary (smooth wall)	Vertical	60	400	11	4
10	12	16	Cement(Type II)+ Gravity injection	Rotary (smooth wall)	Vertical	60	400	11	5
12	14	17	Cement(Type II)+ Gravity injection	Rotary (smooth wall)	Vertical	60	400	11	6
11	13	15	Cement(Type II)+ Gravity injection	Rotary (non- smooth wall)	Horizontal	60	400	11	7
9	10	12	Cement(Type II)+ Gravity injection	Rotary (smooth wall)	Horizontal	60	400	11	8

A site was prepared for carrying out this research study with definite dimensions and depth and its floor and walls were coated with a proper coating to prevent weathering. Then the required physical, mechanical, chemical and mineralogical tests were performed on the soil site. In continuing, the place for nail implantation were determined. After marking their implementing place, the single foundations in 120×120 cm dimensions with 30 to 40-cm thickness were implemented in their structure. A hole with 5-inch diameter was exerted for drilling nails and grouting operations in their middle part. The foundation implementation aims at raising the level of work due to their protection from surface waters, improved for probable rainfall and creating surface for implementing long-term locking operations of nails, implementing smooth surface and balance for lodgment of nail anchoring jack and preventing heterogeneous subsidence and controllable subsidence value while exerting loan. The contracted foundation were 300 kg/cm^3 grade concrete which were armed with reinforcement network in the middle part with enough loading capacity against the loads. In addition, 6 nails were implemented in real scale with an injected length of 400 cm and free length of 60cm in the mentioned field with different Drilling Type vertically and 2 horizontal nails with 15 degree angle to horizontal with the same details were implemented for studying the effect of drilling type on friction behavior and their effects on tensile strength and creeping behavior of nails (Table 2). The eight series of test results that are shown in Table 3 represent the influence of drilling type on tensile strength and creep behavior of nails in the horizontal and vertical modes. Graphs of tests 1 and 5 are shown in Fig. 2 for better understanding of the tests.

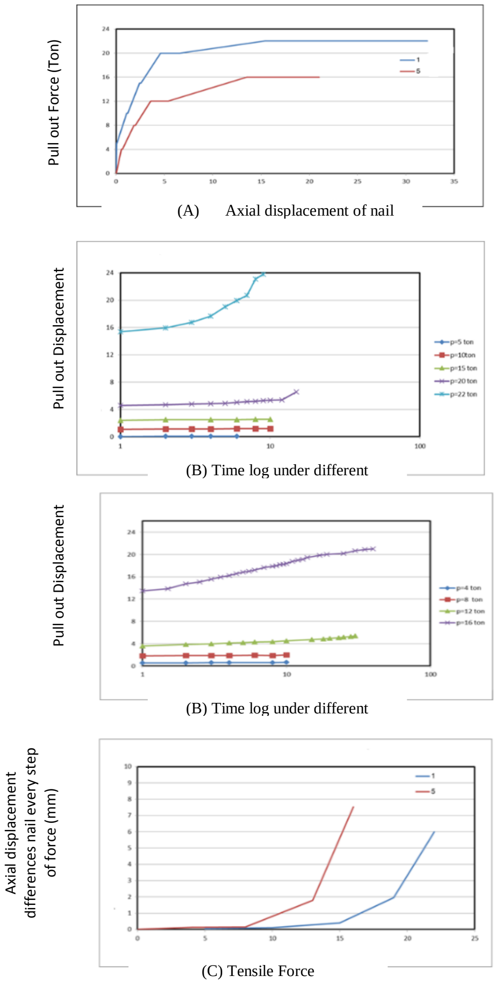

Fig. 2. A) Diagram of tensile force against axial displacement of nails by failure in nails No. 1 and 5, B) Diagram of axial displacement of nails against time log under different tensile loads in nails No. 1 and 5, C) Diagram of tensile force against displacement changes in different stages in nails No. 1 and 5.

3. Conclusions

The results indicate 20 to 25% increase in tensile strength of nails in vertical mode and 15% increase in a horizontal mode implemented with non-smooth drill compared to smooth drill wall. Meanwhile, improving creep behavior of nails is observed via using the non-smooth walls in both horizontal and vertical states. This delays the onset of unacceptable creeping (above 2-mm) and shows more acceptable long-term behavior (see Table 3).