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Experimental Study on Effect of Nailing in Cohesionless Soil

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ABSTRACT: Soil nailing is a construction remedial measure to treat unstable natural soil slopes or as a construction technique that allows the safe over steepening of new or existing soil slopes. There is failures of soil nailing and most happening failure is a pullout failure, so there is a need to identify the pullout resistance of the soil before any construction of soil nail and it's become compulsory if the soil is cohesionless, because pullout failure is generally happen in a cohesionless soil. This paper gives the experimental study to identify pullout resistance of soil in horizontal direction in a cohesionless soil.

I.INTRODUCTION

The work forms a part of continuing research of soil reinforcement at Oxford University, which has included pull-out and direct shear tests of several types of reinforcement using a large scale direct shear apparatus, investigations of the analysis and design theory of unpaved roads on soft soil, and a study of the role of bending stiffness of nails on the stability of nailed slopes. In this research programmed, rather than trying to consider all the numerous parameters which may affect the performance of soil nailing, it was decided to concentrate on relatively simple models using ideal soils, nails and facing walls in the experiments, in the hope of understanding the fundamental mechanics and developing an appropriate design theory of soil nailing. It will then be possible to investigate full scale earth structures constructed with more complex soils and boundary conditions. The most important feature of soil nailing as opposed to the ground anchor technique is that the nail force is passively generated by the displacement of the soil, and the displacement is in turn due to the nail force.

II.RELATED WORK

PULLOUT TEST OF A NAIL: In a soil nail as well as reinforced soil walls the friction between reinforcing element and the surrounding soil plays a major role in improving the stability of earth structures. Since the axial force in a nail is generated by the relative displacement between the nail and the soil, a full understanding of soil nailing requires an understanding of the interaction mechanism between them. It is not however, an easy task to achieve because the interaction is influenced by several factors, such as the properties of the soil, roughness and the stiffness of the nail and the boundary conditions of the test apparatus, as reported by Palmeira and Milligan (1989). Furthermore, the change in stress on the nail due to dilatancy of the soil, when a nail is pulled out, makes the interaction mechanism very complicated and difficult to analyse (Schlosser and Guilloux, 1979).

1. Pull-out Device

The pullout device permits the pullout loads to be applied in a displacement rate controlled manner _up to 6.0 mm/min_. Its maximum pullout capacity is 50 kN, which is adequate for carrying out pullout tests of grouted nails in sandy fills. During the test, the device was mounted on a frame at the required inclination for pulling the nail along its longitudinal direction.

Its reaction force was transferred to a steel beam mounted on the front wall of the tank. A load cell was installed between the nail and the pulling device to measure the pullout force. The displacement of the nail during the pullout was measured by means of LVDT having a maximum travel of 100 mm.

2. TESTING ON SOIL

The quality of the soil on site plays a key role in a construction projects. As a result, need to identify the characteristics of the soil to determine its ability to support the structure soil testing provides a vital data for inform decision making and planning. Soil testing examine the chemical and geotechnical properties, enabling to determine the suitability of soil and assess whether it can accommodate a construction project. To identify the different types of soil on site and their location. To test a soil strength, density, compaction, contamination, organic and sand content, and assess their impact on construction project. To gain the data need to compile technical and safety data reports to support planning applications. To get precise results and observe the development of the soil throughout the project for maximum quality and safety.

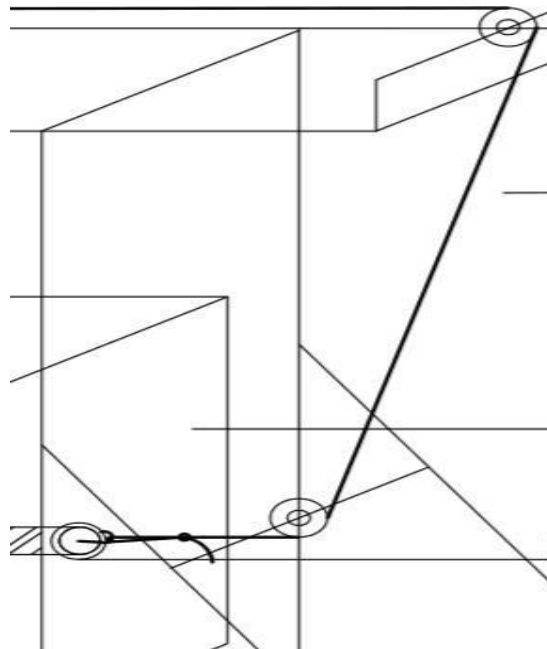


Fig.1 Pulley arrangement used for pulling the nail



Fig.2 Apparatus of Sieve Analysis

1. Procedure

- (a) For soil samples of soil retained on 75 micron I.S sieve.
 - (b) The proportion of soil sample retained on 75 micron I.S sieve is weighed and recorded weight of soil sample is as per I.S 2720.
 - (c) I.S sieves are selected and arranged in the order as shown in the table.
 - (d) The soil sample is separated into various fractions by sieving through above sieves placed in the above mentioned order.
 - (e) The weight of soil retained on each sieve is recorded.
 - (f) The moisture content of soil if above 5% it is to be measured and recorded.
1. No particle of soil sample shall be pushed through the sieves.
 2. No particle of soil sample shall be pushed through the sieves.

OBSERVATION TABLE:

IS SEIVE IN mm	WEIGHT OF FINE AGGRIGATE RETAIN DETERMINATION NO.				WEIGHT RETAIN ED (gm)	CUMULA- TIVE OF RETINED	PERCENT- AGE PASSING (%)	PERMISSIBLE PERCENTAGE PASSING AS PER IS:383
	1Kg	2Kg	3Kg	Av g.(gm)				
4.75	0.03	0.02	0.02	23	23	23	2.3	97.7
2.36	0.02 5	0.01 5	0.02	20	20	43	4.3	95.7
1.18	0.03	0.03	0.04	33	33	76	7.6	92.4
0.6	0.61	0.52 5	0.68 5	60 6	606	682	68.2	31.8
0.2	0.29	0.39	0.22	30	303	985	98.5	1.5

2. Calculation:

The percentage of soil retained on each sieve shall be calculated on the basis of total weight of soil sample taken. Cumulative percentage of soil retained on successive sieve is found.

$$D_{10} = 310 \mu, \quad D_{30} = 580 \mu, \quad D_{60} = 960 \mu,$$

$$C_u = D_{60}/D_{10} \\ = 0.96 / 0.31$$

$$= 3.09$$

$$C_c = (D_{30})^2 / (D_{60} \times D_{10}) = 0.58^2 / (0.96 \times 0.31) = 1.13$$

C_c should be greater than 1.

Hence, uniformly gap graded soil.

III.PYCNOMETER TEST

For determination of specific gravity of soil by Pycnometer'. Volumes of soil solids and water are taken same. The volume of known weight of soil grains can be obtained by using a container of known volume; and the Archimedes Principle, "that a body submerged in a volume of water will displace a volume of water equal to the volume of the submerged body." The container of known volume as the volumetric flask or Pycnometer, which holds a standard volume of distilled water at 20°C. At temperature more than 20°C, the volume will be slightly more, below 20°C, the volume will be slightly less. In routine work, generally, tap water is used instead of distilled water.

Specific Gravity of Soil Definition: The specific gravity of soil is defined as the unit weight of the soil mass divided by the unit weight of distilled water at 4°C. It is some times required to compare the density of the soil solids to the density of water. This comparison is in the form of ratio and is termed as the specific gravity of the soil. Together with the soil moisture content and unit weight, specific gravity is frequently used to solve for the various phase relationships, such as void ratio, porosity, and degree of saturation. Specific gravity is also required in the calculations associated with the grain size analysis, the consolidation, and compaction (Standard Proctor Test and Modified Proctor Test).



FIG.3 PYCNOMETER

3. Procedure:

1. Weigh the empty and dry volumetric flask / Pycnometer to the nearest 0.01 gram and record the weight as W₁.
2. Take about 100 grams of oven dried soil and put it into the Pycnometer.

3. Now weigh the Pycnometer and dry soil to the nearest 0.01 gram and record the weight as W2.
4. Add water in the Pycnometer until about it is two thirds full. Gently and carefully agitate the mixture.
5. Add some more water in the Pycnometer until the bottom of the meniscus is exactly at the volume mark. Weigh the Pycnometer and record it as W3.
6. Empty the pycnometer and wash it. Then fill it with water up to the mark and weigh as W4.
7. Repeat the above Procedure three times.
8. Record the temperature of soil water mixture by the thermometer.
9. Specific Gravity of Soil is then, computed by diving the weight of soil by the weight of an equal volume of water as below.

Observations and Calculations

Note: 1. wt. weight.

2. gm = gram.

3. Gs = Specific Gravity of Soil.

Soil sample = 200gm

W1 = Weight of pycnometer empty = 0.645 Kg W2 =

Weight of pycnometer with sand = 0.845 Kg

W3 = Weight of pycnometer with sand + water = 1.70 Kg W4 =

weight of pycnometer with water = 1.420 Kg

$$Gs = (W2 - W1) / \{(W4 - W1) - (W3 - W2)\}$$

$$Gs = (0.845 - 0.645) / \{(1.420 - 0.645) - (1.7 - 0.845)\}$$

Specific Gravity = 2.73

4. Result

Average Specific Gravity of Soil = 2.73

5. Precautions

1. Weigh the Pycnometer carefully.

2. Shake the Pycnometer well to extract air by fully saturating the soil.
3. Do not shake vigorously.

IV.RESULT AND ANALYSIS

OBSERVATIONS:

Sr.no	Nail diameter(mm)	Applied load in(kg)	Applied load in (N) Or (W)	u	Pull out Force (N) or T3	Displacement (cm)
1.	6	11	108	0. 2	211.49	9
2.	6	15	147	0. 2	287.51	9.5
3.	6	19	186	0. 2	401.86	10
4.	6	22	216	0. 2	423	11

ii. Graph between Displacement and Pullout Force

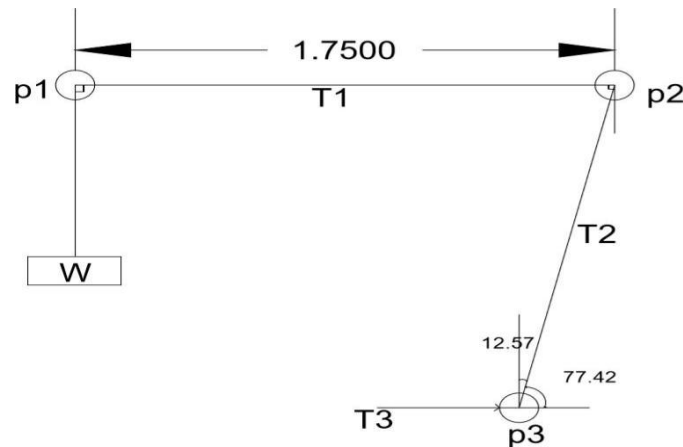
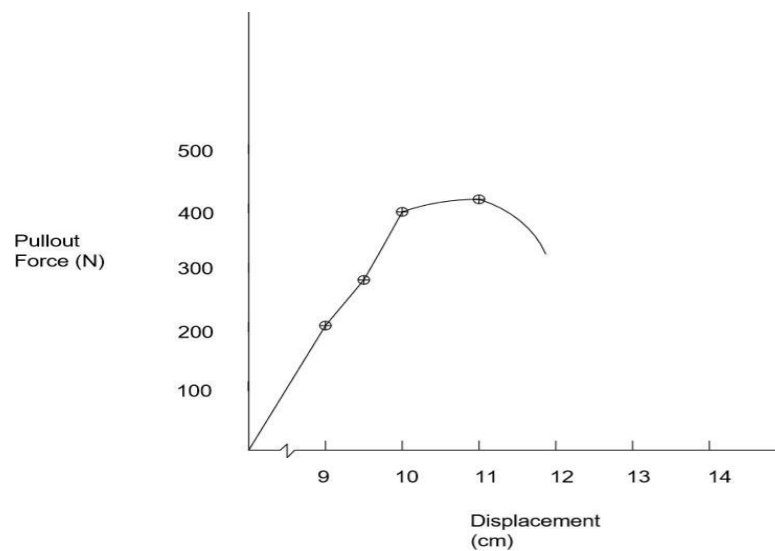


FIG.4 FREE DIAGRAM



The above graph represent the displacement of the nail is plotted on X- direction and the Pullout force is taken on Y- direction. As shown in fig.6.2 the Peak Pullout force is 423N at which displacement is 11cm and after that the nail is fully pull out.

iii. Calculation: Calculation of Pullout Force

A. For 11 kg Applied load:-

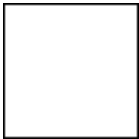
1) For pulley p1,

$$\text{Slipping} = (T1/w) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ & $w=108\text{N}$

$$T1=?$$

$$\text{So, Slipping} = (T1/108) = e^{0.2 \times \pi/2}$$



$$T_1 = 147.86\text{N}$$

2) For pulley p2,

$$\text{Slipping} = (T2/T1) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ & $T1=108\text{N}$

$$T2=?$$

$$\text{So, Slipping} = (T2/147.86) = e^{0.2 \times \pi/2}$$



$$T_2 = 202.43\text{N}$$

3) For pulley p3,

$$\text{Slipping} = (T3/T2) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=0.219$ & $T2=202.43\text{N}$

$$T3=?$$

$$\text{So, Slipping} = (T3/202.43) = e^{0.2 \times 0.219}$$

B.For 15 kg Applied load:-

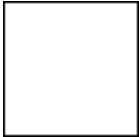
1) For pulley p1,

$$\text{Slipping} = (T1/w) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ & $w=147\text{N}$

$$T1=?$$

$$\text{So, Slipping} = (T1/147) = e^{0.2 \times \pi/2}$$



$$T_1 = 201N$$

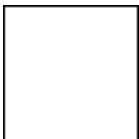
2) For pulley p2,

$$\text{Slipping} = (T_2/T_1) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ & $T_1=201N$

$$T_2=?$$

$$\text{So, Slipping} = (T_2/201) = e^{0.2 \times \pi/2}$$



$$T_2 = 275.19N$$

3) For pulley p3,

$$\text{Slipping} = (T_3/T_2) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=0.219$ & $T_2=275.19N$

$$T_3=?$$

$$\text{So, Slipping} = (T_3/275.19) = e^{0.2 \times 0.219}$$



$$T_3 = 287.51N$$

C.For 19 kg Applied load:-

1) For pulley p1,

$$\text{Slipping} = (T_1/w) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ & $w=186N$

$$T_1=?$$

$$\text{So, Slipping} = (T_1/186) = e^{0.2 \times \pi/2}$$



$$T_1 = 254.65N$$

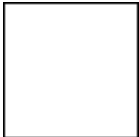
2) For pulley p2,

$$\text{Slipping} = (T_2/T_1) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ &

$$T_1=254.65\text{N } T_2=?$$

$$\text{So, Slipping} = (T_2/254.65) = e^{0.2 \times \pi/2}$$



$$T_2 = 384.64\text{N}$$

3) For pulley p3,

$$\text{Slipping} = (T_3/T_2) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=0.219$ & $T_2=384.64\text{N}$

$$T_3=?$$

$$\text{So, Slipping} = (T_3/384.64) = e^{0.2 \times 0.219}$$

$$T_3 = 401.86\text{N}$$

1. D.For 19 kg Applied load:-

1) For pulley p1,

$$\text{Slipping} = (T_1/w) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ & $w=216\text{N}$

$$T_1=?$$

$$\text{So, Slipping} = (T_1/216) = e^{0.2 \times \pi/2}$$



$$T_1 = 295.727\text{N}$$

2) For pulley p2,

$$\text{Slipping} = (T_2/T_1) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=\pi/2$ &

$$T_1=295.72N \quad T_2=?$$

$$\text{So, Slipping} = (T_2/295.72) = e^{0.2 \times \pi/2}$$



$$T_2 = 404.88N$$

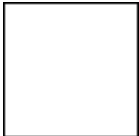
3) For pulley p3,

$$\text{Slipping} = (T_3/T_2) = e^{u \times \beta}$$

Where, $u=0.2$, $\beta=0.219$ & $T_2=404.88N$

$$T_3=?$$

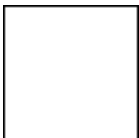
$$\text{So, Slipping} = (T_3/404.88) = e^{0.2 \times 0.219}$$



$$T_3 = 423N$$

2. Calculation Pullout Resistance

The pullout resistance (q) of the nail was obtained by dividing the peak pullout



force by the active surface area of the nail, which is

$$q_s = p/\pi DL$$

where, p- peak pullout force interpreted from the pullout force-

displacement curve (KN)

D- diameter of the nail,

L- length of nail in contact with the soil

$$q_s = 423 / 6 \times \pi \times 0.6096$$

$$= 35.81 \text{ N/m}^2$$

iv. **RESULT:**



The Pullout Resistance of the Nail in Cohesion less soil having diameter 6mm and length 2ft is....35.81N/m²...

V.CONCLUSION

A Laboratory study was conducted to investigate the behavior of soil nail imbedded in Cohesionless soil. The Pullout Resistance of the Nail in Cohesion less soil having diameter 6mm and length 2ft is about 35.81N/m². The interfaces parameter of the grouted nail from pullout test is fairly close to soil strength parameters determine by the direct shear box test. The study has also demonstrated that the laboratory test can provide the fairly good estimation of the field pullout resistance.

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