Evaluation of cone penetration resistance of loose silty sand in the calibration chamber

Evaluation de résistance de pénétration de sable lâche dans une chambre calibrée

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ABSTRACTS: This paper investigates influence of silt presence on cone penetration resistance of a silty sand. The study includes 21 penetration tests in saturated silty sand where the samples had been prepared in a rigid thick walled steel cylinder-testing chamber. The penetration tests were carried out using a standard electronic type cone. The samples were prepared with several different silt contents ranging from 10 to 50 percent. Specimens were consolidated to several different effective confining stresses including 100,200,300 Kpa prior to testing. This study showed that, the amount of silt presence in sand is an important parameter affecting cone resistance. As the silt content increases, the tip resistance of cone decreases. Confining pressure and drainage condition also affect cone penetration resistance. The recorded excess pore pressure during sounding was also increased by increasing silt amount.

RESUME: Dans cet article on e tudie l influence de silt sur la resistance de pénétration de sable. Cette étude concerne 21 d'essai de pénétration dans le sable sature, des échantillons ont et préparent dans un cylindre émacier. Les essais ont fait en utilisant dune système électronique standard. Les échantillons sont prépares avec différent contenu de silt (de 10 a 50 pourtant. Les échantillons sont consolides avec différente contrainte de confinement effective (100, 200,300 KPa. Ce travail a montre que le contenu de silt dans un sable est un paramètre important et avoir un effet sur la résistance. En augmentant le contenu de silt la résistance diminue. La pression de confinement et la condition de draine aussi influe sur la résistance de pénétration. Les résultats obtenus montrent dune augmentation de lexies de pression interstitielle avec le contenue de silt.

INTRODUCTION

The cone penetration test is a popular in situ testing for soil characterization. However, the interpretation of in situ test results due to its nature has remained empirical.

Soil properties are not directly measured with this devise, but must be derived from existing empirical correlations. Use of calibration chambers has proven to be valuable tool in the development of the correlations. In an attempt to improve the interpretation of in situ test results, use of calibration chamber to study the behavior of uniform sands has recently become popular. (Chapman 1975,Schmertmann 1976, Bellotti, Bizzi And Ghionna 1982, Parkin and Lunne 1982, Been and Jefferi 1985, Sladen 1989, Salgado et al, 1998). But for silty soils su as silty sands, few research results have been reported un recently.

EQUIPMENT

Baziar and Ziaie (2000) have presented detailed description the calibration chamber and related equipments used in th study. The testing chamber is basically consisted of rigid thi walled steel cylinder of 0.76-m internal diameter and 1.50 height, with removable top and bottom plates. A rubb membrane cap, forming a flexible diaphragm is used to app load to the top of the sample, simulating a big odeometer devi and producing samples with different stress histories. Tl chamber is capable of housing a 0.76 diameter by 1.0-m heig soil sample. The main part of the chamber is a 1.0-cm thi cylindrical shell bolted to circular top and bottom plates of 2 cm thick. The standard piezocone is inserted into the chamb by a hydraulic system. Standard piezocone used in th investigation has 10 cm^2 projected tip area and a 150-cm friction sleeve area. In this penetrometer, friction sleeve is sit immediately behind the cone tip. The filter element for readi pore water pressure is located immediately behind the cone tip. The piezocone is advanced through soil at a constant rate of 20 mm/sec.

SOIL SAMPLE

Approximately 60 tons of Tello clean fine sand was acquired for this research. This alluvial soil is a fine clean sand without any clay or silt particle and has specific gravity of 2.6. A typical gradation curve

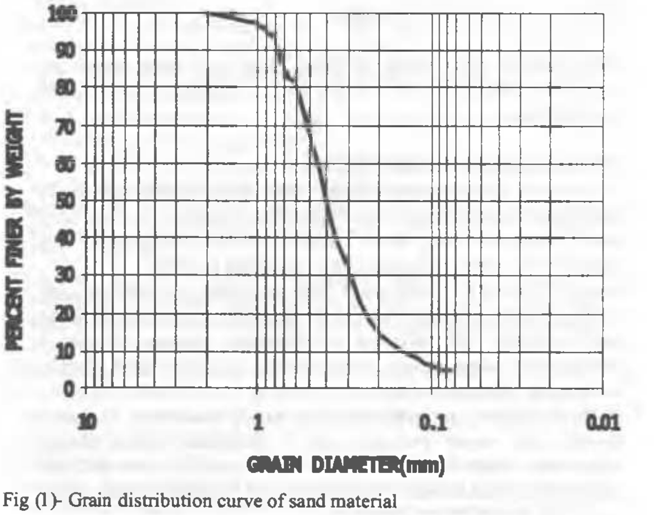


Fig (1)- Grain distribution curve of sand material

of this material is shown in Fig1. In order to determine the influence of

silt presence on CPT results, the pure silt was obtained from grinding of Tello fine sand. Approximately 10 tons of silt material was obtain to prepare different mixture of silt and sand.

EXPRIMENT PROCEDURE

The test was performed in five stages including preparing of sample, saturation, consolidation, CPT sounding and evacuation. Before

Filling the testing cylinder with dry sand, a soil filter grading from coarse sand to fine gravel was formed at the bottom. To saturate the sample, the top plate was fixed on the chamber and vacuum was applied inside the chamber through the top connection for 30 minutes. Then the bottom water supply was opened, and the filter was flooded quickly and a uniform slow upward flow was followed. After the sample was setup, the normal testing procedure consisted of sample consolidation and/or additional over consolidation, were followed by cone penetration test.

Test No.	Type of Material	Silt Percent (%)	Consolidation Pressure (Kpa)	q_c (Mpa)
1	Clean Sand	0%	100	1.6
2			200	3.5
3			300	4
4	Silty Sand	10%	100	1.4
5			200	3
6			300	3.4
7		15%	100	1.3
8			200	2.6
9			300	3
10		20%	100	1.2
11			200	2.2
12			300	2.8
13		30%	100	1
14			200	2.6
15			300	3.6
16		40%	100	0.65
17			200	1.4
18			300	2.4
19		50%	100	0.4
20			200	0.8
21			300	2.2

Table (1)- Results of CPT sounding

The samples were made of clean sand and sand containing 10,15,20,30,40,50 percent of silt and consolidated to 100,200, and 300 Kpa.

PENETRATION TEST RESULTS

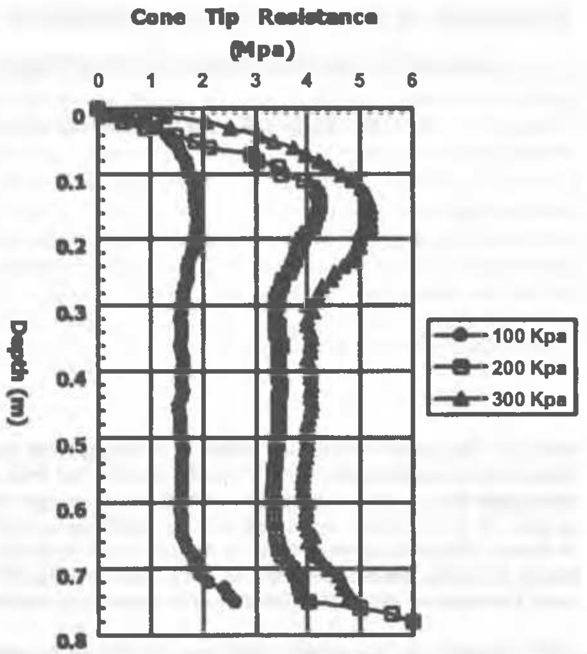
A total of 21 cone penetration tests were performed in 21 calibration chamber specimens including 4 sample of clean sand and 13 sample of silty sand. Table 1 presents the summary and results of the tests, reported in the presented analysis.

Figure 2 shows a typical result from continues penetration with pore pressure measurement in a normally consolidated clean sand samples with different consolidation pressure. Figure 3 indicates the same values corresponding to a silty sand sample containing 15 percent silt.

In these Figures, q_c represents the cone tip resistance, U shows excess pore water pressure and f_s indicates friction sleeve resistance. It should be noted that in this sample, there is a 20-cm top filter and 80 cm bottom filter and the total length of soil sample is about 70 cm. It can be seen that the q_c value increases in depths of sample and reach to maximum value in top filter zone area, then reduce and remain constant along the soil sample. This pattern is shown in both clean sand and silty sand samples. Excess pore water pressure is approximately zero in top filter zone (20 cm of upper part of each sample) of each sample. In clean sand samples in order to existance of full drinage condition, the excess pore water pressure readings are negliable, but in silty sand samples, excess pore water pressure grows up and receive to constant value during the main part of samples and then reduce to zero in down filter.

DISCUSSION OF TEST RESULTS

Results of laboratory penetration tests show the influence of confining pressure on tip resistance. Figure 2 shows the tip resistance curves in clean sand specimens with different confining pressure including 100,200,300. It is clear that the cone tip resistance increases with increasing the confining pressure in clean sand, as it would be expected. In silty sand samples also the cone tip resistance increases when the confining pressure increases (Figure 3).



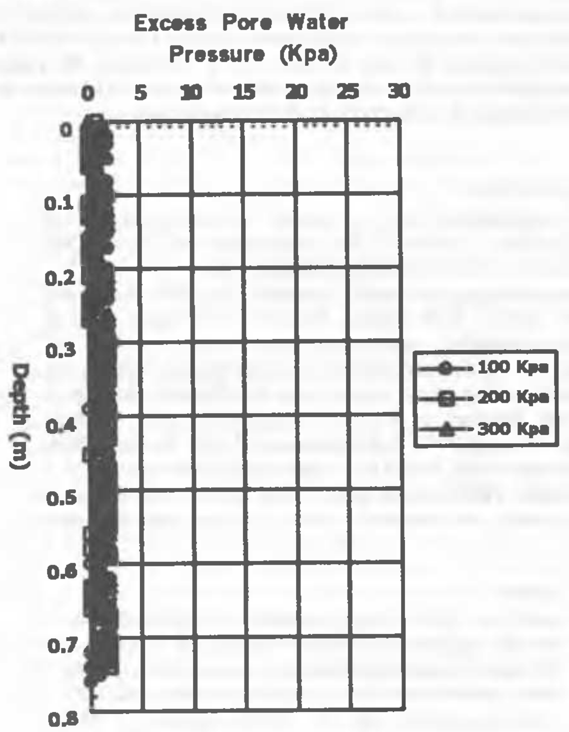


Fig (2)-CPT results in Clean Sand
in different confining pressure

It is clearly shown that the confining pressure has a major effect on q_c as others (Baziar and Ziaie 1998, Baziar and Dobry, 1995) have previously reported.

Value of cone tip resistance versus fine content for different confining pressure presented in fig (4). Small value of silt content in sand causes the system to act like a granular matrix and the contact of coarse grains dominates the behavior of the soil pack (0 to 30 percent silt content).

However more increase in silt content, causes the granular behavior changes to fine particle behavior and with generation of pore water pressure(30 to 50 percent silt content). It can be seen that, in general qc decreases when fine content increases, But qc decreases more gently in 30-50 percent silt compared with 0 to 30 percent silt. In low percent of silt (0-20%), system acts similar to a coarse granular matrix with fine material fillers. Behavior of soil sample in this case is related to contacts of coarse grain and

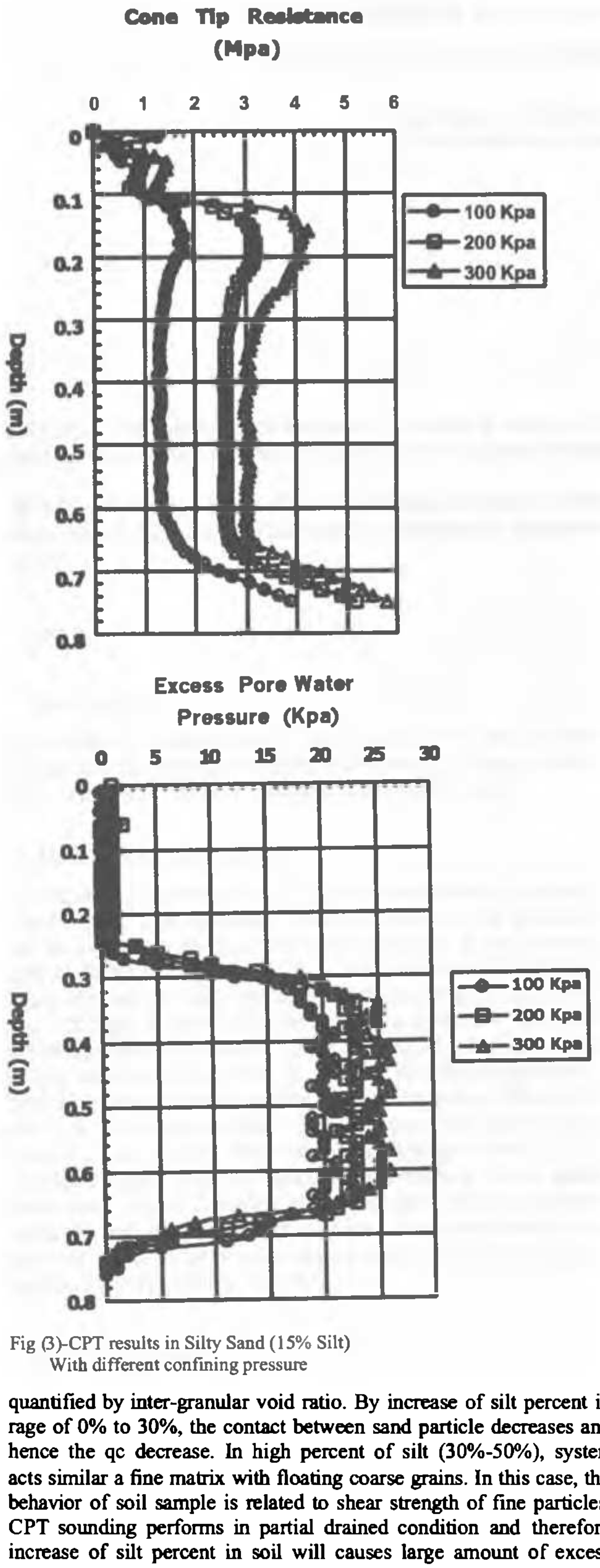


Fig (3)-CPT results in Silty Sand (15% Silt)
With different confining pressure

quantified by inter-granular void ratio. By increase of silt percent in rage of 0% to 30%, the contact between sand particle decreases and hence the qc decrease. In high percent of silt (30%-50%), system acts similar a fine matrix with floating coarse grains. In this case, the behavior of soil sample is related to shear strength of fine particles. CPT sounding performs in partial drained condition and therefore increase of silt percent in soil will causes large amount of excess pore water pressure and decreases in the cone tip resistance.

CONCLUSION

The results obtained from piezocone tests in silty sand materials have indicated that, with increase of silt percent in soil sample, the cone tip resistance decreases and also it is concluded that the cone tip resistance increases with increasing the confining pressure in silty sand material. This study suggests that drainage condition and excess pore water pressure are another parameters

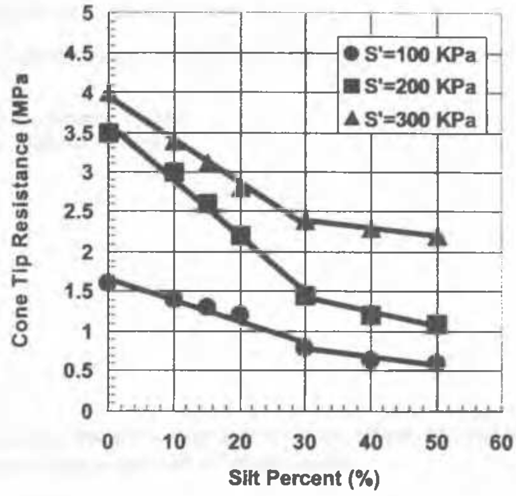


Fig (4) – qc versus Fine Content

that need to be quantified for interpretation of cone penetration resistance of sand containing significant amount of fines.

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