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Study on effect of cone diameter in cone penetration test on sandy soil

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ABSTRACT

Cone Penetration Test (CPT) is an exploration tool used in site investigation and soil exploration. A considerable amount of experience and knowledge have been gained on the value of this method in the understanding and evaluation of the local soils behaviour. Local river sand has been tested using CPT with different void ratio and different cone diameters of 25mm, 20mm, 15mm. This study extracts about the effect of cone diameter in cone penetration test on sand, effect of moisture content on diameter, effect of Void ratio on cone diameter. It can be concluded that the greater the diameter, the lesser will be the Depth of penetration and Higher Penetration resistance.

KEY WORDS: Cone Diameter, Cone Penetration, CPT

1. INTRODUCTION

CPT has been used for penetration test for quality control in sand of very uniform water content. It can also be derived to find the relationship between the cone penetration resistance and the liquefaction strength of the sand. It can also be used to estimate material properties of the soil such as its stiffness and strength in case of sub grade soil. Deepika. Chukka, Chakravarthi (2011) stated that as the void ratio decrease due to the effect of moisture content on DCPI, the value decreases as the bearing ratio also increases. It is also apparent from these conclusions that there are many soils that do not easily fit the idealized "sand" or "clay" behaviour, on which much of soil mechanics depends.

Zakia Baghdadi, Fouad Ghazali and Ahmed Khan (2009) Provision of sleeve pipe around penetration rod greatly helped in accurate measurement of cone resistance *(q_c)* alone. The cone resistance is found to vary linearly with depth or surcharge for the same relative density of a homogeneous (sandy) soil strata. Abouzar Sadrekarimi (2012) the pore-pressure sensor, in particular, provides valuable information on thin layers of more, or less, permeable material, within a soil matrix. Isotropic consolidation has no effect on the shear strength of the soil at large displacements. Hansbo (1957) made an extensive study of cone penetration testing with the Scandinavian fall cone device. He attempted to correlate penetrations of essentially four different cones (60º cones weighing 10g and 60g and 30º cones weighing 100g and 400g) with field vane shear strengths for a number of Scandinavian, particularly Swedish soils, and established a relationship.

2. METHODOLOGY

Properties of Sand: The locally available river sand is used in this study to conduct cone penetration test with varying diameters. The index properties of the sand used in this research work is furnished in table 1. Fig. 1 shows the grain size distribution of the soil sample taken for the study. The standard compaction test is conducted on the soil sample as per IS standards and the characteristic curve is shown in fig. 2.

Table.1. Properties of sand

Description	Sand
Specific Gravity, G	2.6
D_{10}	0.32
D_{30}	0.45
D_{60}	1.3
Cc	0.49
Cu	4.06
$\gamma_{dmax,}$ g/cc	1.89
OMC %	14.8
e_{max}	0.629
e_{min}	0.525
e_{avg}	0.577
IS Classification	SP

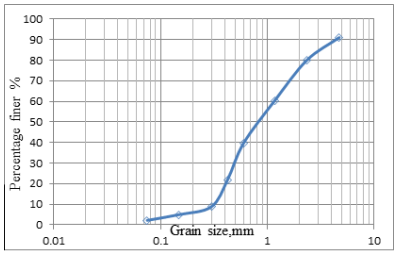

Figure.1. Particle size distribution curve

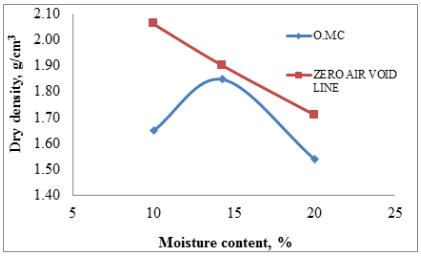

Figure.2. Compaction characteristics of sand used

Cone Penetration Test: The test method consists of pushing an instrumented cone, with the tip facing down, into the soil sample placed in a tank of size 20cm x 20cm x 20cm, at a controlled rate. To study the effect of diameter on the void ratio and effect of moisture content, cones with varying diameter 15mm, 20mm and 25mm are used in the research work. The test setup for the experiment is shown in fig 3. The test setup consists of a loading frame with load cell and a data logger to record the penetration resistance. Depth of penetration is recorded using dial gauge as shown in fig.3.

CPT is carried out by progressively penetrating the soil under static force. Usually 60° cone (10-15 cm^2 area) is pushed at the rate of 1-2 cm/sec approximately till the final depth is reached. The test is conducted in different states namely medium dense state and dense state. Also to understand the effect of moisture content on penetration resistance, the soil sample is tested at two different moisture contents namely 10% and 18%. The moisture contents are selected randomly with one more than the OMC (15%) and the other less than the OMC.

3. RESULTS AND DISCUSSION

The penetration resistance and depth of penetration is carefully recorded for each test with varying cone diameter, varying soil states and moisture contents. From the test results curves are drawn between penetration resistance and depth of penetration. The test results clearly show that the cone diameter plays a major role in deciding the penetration resistance and depth of penetration. Fig.4, shows the relationship between penetration resistance and depth of penetration in the case of medium dense state soil in dry condition.

Figure.3. Test Setup of Cone Penetration on sand

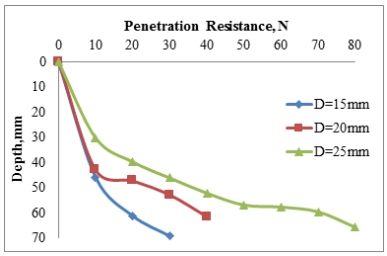

Figure.4. Relationship between penetration resistance and depth in the medium dense state

From the fig.4, it can be seen that the 25mm diameter takes more load than its smaller counterparts at a given depth. At a specific depth (say 30mm),uniformity is seen in 15 and 20mm diameter of cone while a greater cone diameter such as 25mm diameter show more penetration resistance due to larger skin friction of the cone.

Fig.5, shows the relationship between Penetration resistance and depth of resistance of the test conducted on soil in the dense state. It can be seen that the soil state, i.e. dense state offer more penetration resistance when compared to medium dense state. In this case also it is clear that greater diameter shows more penetration resistance than that of lesser diameter cone.

To understand the effect of moisture content, the relationship between penetration resistance and depth of penetration is drawn as shown in fig. 6 for the soil in the medium dense state with 10% water content. When compared to dry state of the soil the increase in the penetration resistance is 1.25 times more in the case of soil with 10% water content.

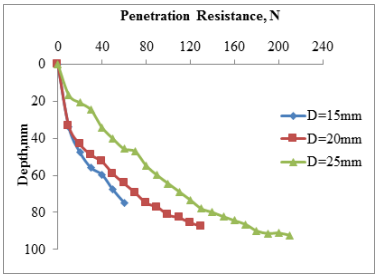

Figure.5.Relationship between penetration resistance and depth in the dense state

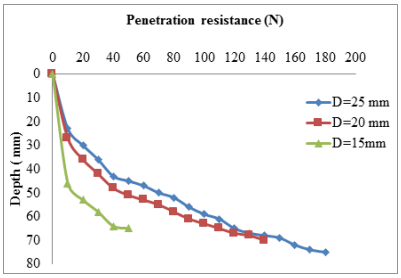

Figure.6.Relationship between penetration resistance and depth in the medium dense state with 10% water content

The relationship between penetration resistance and depth with 18% water content in soil in the medium dense state is shown in fig.7. In this case both 20mm diameter cone and 25mm diameter cone shows same behaviour, but depth of penetration is more in the case of 25mm diameter cone. Similarly the tests are conducted with 10% and 18% moisture content for dense state. Fig. 8 shows the relationship between the penetration resistance and depth in the dense state with 10% moisture content.

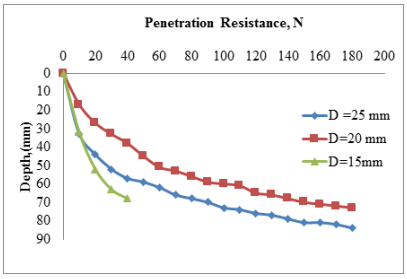

Figure.7. Relationship between penetration resistance and depth in the medium dense state with 18% water content

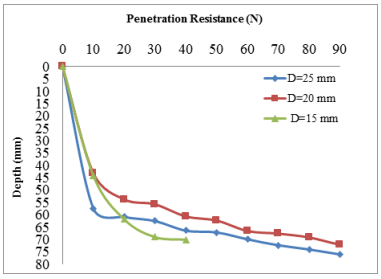

Fig.8. Relationship between penetration resistance and depth in the dense state with 10% water content

In this case also the cone diameters 20mm and 25mm show the similar behaviour. When compared to dry state the penetration resistance is in lesser, which may be due to the presence of moisture content.

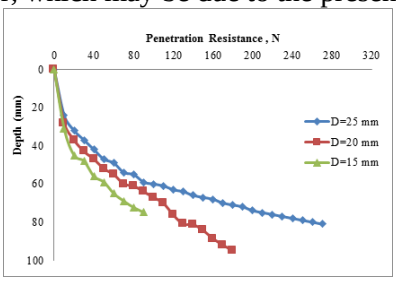

Fig.9. Relationship between penetration resistance and depth in the dense state with 18% water content

Fig.9, shows the relationship between penetration resistance and depth of penetration in the dense state with 18% moisture content. In this case the 25mm diameter clearly shows the increase in the penetration resistance, when compared to other diameter cones. Also the increase in the penetration resistance is around 2.1 times more than that of soil with 10% moisture content.

4. CONCLUSION

CPT has advantages over the traditional Standard Penetration Test (SPT) as it's faster and requires less labour. CPT has been used for penetration test for quality control in sand of very uniform water content. It has greater accuracy with continuous digital data record enabling the analysis in real time. Other advantages are its better resolution, its versatility and attainment of pore water pressure, dynamic soil properties, etc. The following conclusions are drawn from the test results.

- In a Medium dense state of sand the larger diameter cone shows more penetration resistance and also more depth of penetration.
- In the dense state, it is obvious that the penetration resistance increases when compared to medium dense state.
- As it is not always possible to have dry state of the soil, the presence of moisture content clearly shows the effect of cone diameter in the penetration resistance.

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