The Effectiveness of Different Rate of Penetration With Different Shapes in Cone Penetration Test (CPT) on Recess Batu Pahat Soft Soil

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الخلاصة

يستخدم اختبار اختراق المخروط على نطاق واسع لتقييم خصائص التربة في الموقع و وصف الموقع. والنتائج المباشرة من اختبار اختراق المخروط هي مقاومة المخروط ، احتكاك الجوانب وضغط الماء داخل المسام، اليوم تشهد أغلب مناطق العالم انخفاضًا في مساحة التربة الجيدة من أجل التنمية ، وبالتالي يحتاج المهندسون إلى حل بديل في البناء على التربة الرطبة. الهدف من هذه الدراسة هو قياس مقاومة الأطراف باستخدام أنواع مختلفة من مجموعة أشكال بمعدلات اختراق مختلفة. شكلى الكرة والحرف تى بار تعرضان العديد من المزايا بدلا من الشكل المخروطى التقليدي لاختبار قوة مقاومة الاختراق للتربة الناعمة .معدلات سرعة الاختراق المستخدمة كانت كالتالى 5مم / ثانية ، 20 مم / ثانية ، 40 مم / ثانية. أظهرت النتائج المتحصلة من الشكلين تي بار والكرة ارتفاعًا يتراوح ما بين 2–4 مرات وأعلى بمقدار 3–5 مرات على التوالي مقارنة بالشكل المخروطى التقليدي عندما أستخدمت في تربة باتو باهات.

الكلمات المفتاحية: معدل الاختراق ، اختبار اختراق المخروط ، مقاومة المخروط ، شكل الكرة ، شكل تى

Abstract:

The cone penetration test (CPT) is widely used for the evaluation of in-situ soil properties and site characterization. The direct results from the cone penetration test are cone resistance, sleeve friction and pore water pressure. Today every part

of the world experience a decrease in the good soil area for development and therefore engineers need to have an alternative solution in construction on soft soil. The aim of this study was to measure the tip resistance for the different type of tips shape at different rate of penetration using the conventional cone, ball and T-bar tips. The ball and T-bar tips offer several advantages to conventional tip used for the in-situ estimation of penetration resistance and strength of soft soil. The rates of penetration used were 5 mm/s, 20 mm/s, 40 mm/s. The results based on tip shapes showed that the ball and T-bar give 2-4 times higher and 3-5 times higher respectively than the standard tip. For Batu Pahat clay, tips with higher surface area gave better results and based on the tip shapes used in this, the T-bar tip gave better results. For the penetration rate .

Keywords: Rate of penetration, Cone penetration test, Cone resistance, Ball shape, T-bar shape, Tip resistance.

1. Introduction

The cone penetration test (CPT) is among the most popular site investigation methods that provide ground data with simple, rapid, accurate and economic process. The cone has several built in electronic sensors such as pore pressure meter and load cells and it pushes into the ground with a constant rate and the soil parameters can be continuously measured. [1,2]

One of the most common parameters measured from the CPT is the tip resistance. The value can be calculated by load cell and projected area of cone shape.

Instead of the conventional CPT, T-bar or Ball penetration tests (these tests will be called TPT and BPT, respectively hereafter) have gained attention .As more detailed description of these penetration tests will be presented in the following section, the most significant advantage of TPT and BPT over the Conventional CPT is its accuracy in measurement of the tip resistance, although the whole penetration resistance increases because of large cross section area of TPT or BPT. Using TPT and BPT, site investigation was carried out with different of penetration rate 5mm/sec, 20mm/sec and 40mm/sec, however the objective of this paper is to determine the tip resistance to overcome the problems of the CPT in soft soil and to assess the effectiveness of tip shape in Batu Pahat soft soil.

2. Literature review

According to Dung et al, were carried out the ball penetration test by using a 20 ton capacity CPT machine which is able to conduct the CPTU in dense similar to that of the CPTU except that the balls were used Instead of the cone tip. To evaluate the variation of the ball factors with respect to ball Sizes, Four different

ball sizes were used as illustrated in Fig (1). The balls Type-1 to Type-3 were made of duralumin while the smallest size was additionally made of copper.

Type 4 shows a step of the BPT at the moment just before the ball Type-2 was carried out. Table (1) shows basic parameters of the balls. In study, the balls were made to associate with the cone of 15 cm², Thus the ball connector diameters were all the same of 4.37 cm. The projected area is the cross sectional area of the ball corresponding to the maximum diameter, and the projected area ratio is the ratio of the cone cross sectional area to the ball projected area. [3]

Fig (1). Ball Types Used for the Tests [3]

Table (1): Basic Parameters of The Balls [3]

Parameter	Type 1	Type 2	Type 3	Type 4
Diameter (cm)	11.28	8.74	6.18	4.37
Projected area (cm^2)	100	60	30	15
Area of rod (cm2)	15	15	15	15
Projected area ratio	0.15	0.25	0.5	1.0

Zhou and Randolph, in 2007 they fabricated the cylindrical T-bar and spherical ball shapes because they have become popular as alternative to conventional cone

penetrometer for characteristic the strength of soft sediment and fabricated shapes they offer several important advantages over the cone, including improved resolution of the measured resistance, reduced uncertainty owing to correction for the overburden stress compared with a cone penetrometer. [4,5]

Instead of the conventional CPT, T-bar or ball penetration tests (these tests will be called TPT,BPT respectively hereafter) have gained attention (for example Randolph, 2004). As more detailed description of theses penetration tests will be presented in the following section the most significant advantage of TPT and BPT over conventional CPT is its accuracy in measurement of tip resistance, although the whole penetration resistance increases because of large Crosse section area of TBT, BPT

3. Methodology

Cone Penetration Tests (CPT) :

The cone penetration test CPT tests were conducted using a standard cone dimension of 35.7 mm and a projected area of 10. Penetration rate was carried out at 5mm/sec. 20 mm/sec and 40 mm/sec to get different cone resistance, the intervals recorded readings every 0.01 m. cone resistance was computed from equation no (1).

q_c= cell load/projected area (1)

Where (q_c) cone resistance, cell load, projected area is cross sectional area.

T-bar tests were conducted by unscrewing from probe and replacing it with the T-bar. The T-bar used in this case is similar to the T-bar used by NGI and COFS being 250 mm long and 40mm in diameter with smooth surface. [6]

Tests were conducted in the same as conventional rate of penetration CPT tests although and two rate of penetration one less than conventional rate 5 mm/sec and another one more than conventional rate 40 mm/sec conducted at same situ.

The Ball used in this study rather than to conventional CPT without pore pressure. the diameter of the ball 100 mm and smooth spherical surface however Penetration of the Ball was conducted in the same method as CPT tests at a rate of 20 mm/sec, and two different rates more, first one 5 mm/sec and second is 40 mm/sec, and measurements of intervals 0.01 m. [7]

Fig (2) Cone ,T-bar & Ball shapes used in this study

T-bar, ball, and conventional CPT penetrometers were implemented at Batu Pahat characterized test site The site were chosen based on previous research and characterization indicating the large range of cone resistance in T- bar values more than ball because the projected area of T-bar greater than ball and conventional CPT

Table (2) Results of Tip resistance Penetration Tests in Cone

Rate of penetration	5 mm/sec	20 mm/sec	40 mm/sec
Depth (m)	1-4	1-4	1-4
Cone resistance (Mpa)	0.114-0.171	0.26-0.29	0.21-0.26
Ball resistance (Mpa)	0.56-1.05	0.9-1.19	1.23-1.38
T-bar resistance (Mpa)	1.12-2.63	1.26-1.73	1.41-1.74
Cone resistance (Mpa)	0.23-1.04	0.32-1.05	0.30-1.44
Ball resistance (Mpa)	1.27-2.53	1.33-2.51	1.36-3.03
T-bar resistance (Mpa)	1.15-2.63	1.51-2.88	1.59-3.51

4. Results and Discussion

Influence of shapes .

Cone Shape:

The Testing at the RECESS Batu Pahat site was the first comparative study of the different rate of penetration conducted in soft clay soil. Three rates have been used, one of them smaller than the standard rate of 20mm/s and another one higher than standard rate 40mm/s. The rates were used until 8m depth to evaluate the rate effect on CPT in soft clay. The measured cone resistance q_c are shown in Fig (3).

The data from Table (3) shows that q_c have increased with the increase of Penetration rate. This is in accordance with (Danziger and Lunne 2012), the general trend results between q_c20/q_c40 less affected than q_c5/q_c20 and q_{c5}/q_c40 pointed out in the table and Fig (3).

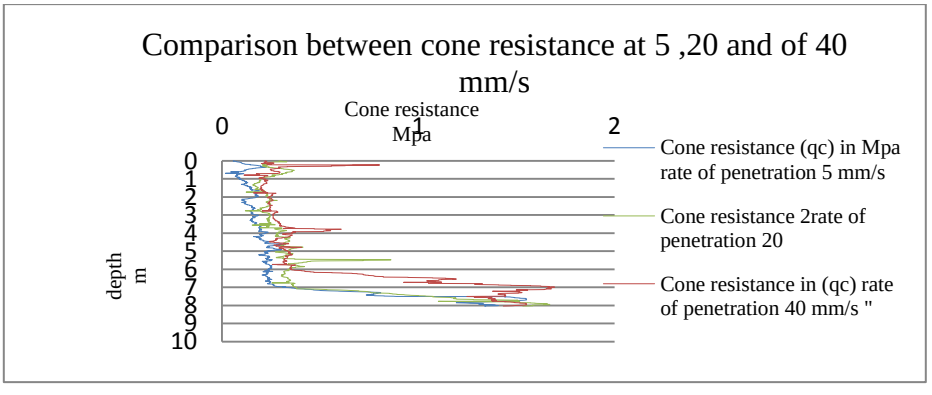

Fig (3) Comparison Between Cone Shape Resistance In Different Rate Of Penetration

Table (3) Difference Between qc5/qc20,qc5/qc40 and qc20/qc40

Depth (m)	q_c5/q_c20 %	q_c5/q_c40 %	$q_c20/q_{c4}0$ %
0-1	30-40	30-70	10-20
1-2	20-40	30-50	10-20
2-3	30-50	30-60	10-20
3-4	20-30	40-60	20-10
4-5	30-40	40-70	10-30
5-6	20-50	10-40	10-20
6-7	20-40	30-40	10-20
7-8	30-50	30-70	20-30

Ball Shape :

When performed BPT in Batu Pahat's soft clay with the various rates 5, 20, 40 mm/s and 80 cm^2. Most of the results showed an increase of resistance with different rate increase, within the first 2 meters $q_{ball}5/q_{ball}20$,

$q_{ball}5/q_{ball}40$ the q_{ball} increased about 30-50% but the difference between q_c20/q_c40 decreased from 10-20%. In lower depths the percent of resistance mostly increases from 0-10%, so the effective rate of penetration when I used the ball shape decreased with the depth, but at the surface I got good results especially with low and high penetration of rate of 5mm/s and 40mm/s. But the resistance of the rate 20,40mm/s is slightly corresponding at depths between 4-6 m. finally the rate of Penetration effected on Batu Pahat soft clay from a ball shape but effectiveness less than the cone shape. Fig (4)

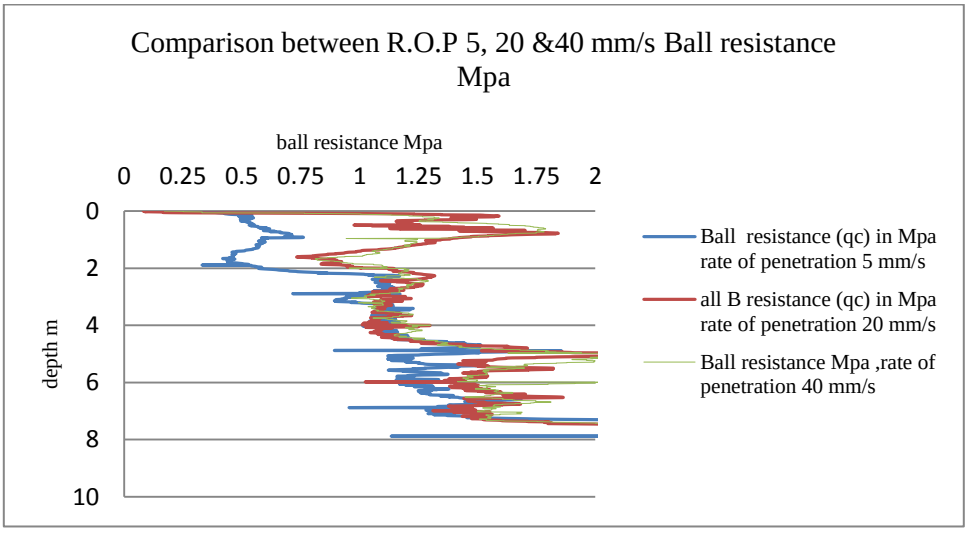

Fig (4) Comparison Between Shape Resistance In Different Rate Of Penetration

Table (4) Difference Between $q_{ball}5/q_{ball}20$, $q_{ball}5/q_{ball}40$ and $q_{ball}20/q_{ball}4$

Depth m	$q_{ball}5/q_{ball}20$ %	$q_{ball}5/q_{ball}40$ %	$q_{ball}20/q_{ball}40$ %
0-1	20-50	30-50	10-20
1-2	40-50	40-60	0-10
2-3	10-30	10-30	0
3-4	1-10	1-10	0
4-5	1-5	1-5	0
5-6	1-4	1-5	0
6-7	10-20	10-30	0-10
7-8	1-10	5-15	1-5

T-bar shape :

When performing TPT in Batu Pahat's soft clay with the various rates 5,20,40mm/s and 100 cm^2, Most of the results showed an increase of resistance when the penetration rate increased according to (Danziger and Lunne 2012) . The T-bar resistance increased about 0 to 10% per $q_{T\text{-}bar}$ 5/$q_{T\text{-}bar}$ 20 and 10% to 20% per $q_{T\text{-}bar5}/q_{T\text{-}bar}40$ in the first three meters but the resistance is more than affected when the different rate of penetration is qc20/qc40, the resistance increased about 0%-10% as pointed out that in Table (5) . The different rate is less affected in the lower depths from 4-8m. The resistance induced from different rates is more corresponding, which means the different rate of penetration is less affected in Batu Pahat soft clay, especially when using a bigger projected area instead of the standard cone.

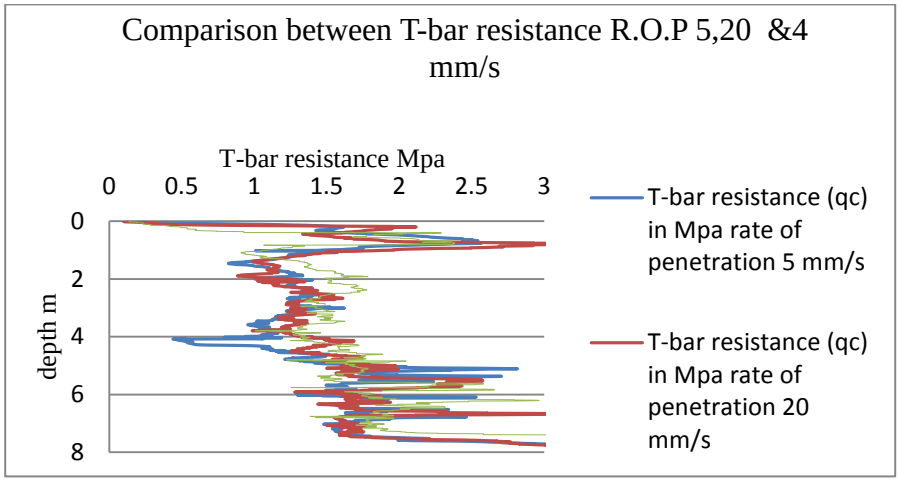

Fig (5) Compare Between Shape Resistance In Different Rate Of Penetration

Table (5) Difference Between $q_{T\text{-}bar}5/q_{T\text{-}barl}20$, $q_{T\text{-}bar}5/q_{T\text{-}bar}40$ and $q_{T\text{-}bar}20/q_{T\text{-}bar}40$

Depth m	$q_{T\text{-}bar5}/q_{T\text{-}bar\ 20}$ %	$q_{Tbar5}/q_{T\text{-}bar40}$ %	$q_{T\text{-}bar\ 20}/q_{T\text{-}bar\ 40}$ %
0-1	0-10	10-20	0-10
1-2	0-10	10-20	0-10
2-3	0-10	10-20	0-10
3-4	1-10	1-10	0
4-5	10-20	10-20	0
5-6	1-5	1-5	0
6-7	1-5	1-5	0
7-8	1-5	1-5	0

5. Conclusion

From in-situ tests carried out at Batu Pahat soft clay site to investigate the effect of tip shape in soft soil, the test was carried out by three different shape standard cone shape, ball and T-bar shape at several depths to evaluate the penetration resistance. The CPT, Ball and T-Bar shapes were carried out at the same speed 5mm/sec, 20mm/sec and 40 mm/sec. The conclusion as follows :

1. The measured cone penetration resistances, ball and T-bar penetration resistance (q_{cone}, $q_{T\text{-}bar}$, q_{ball}) generally, smaller shape produces smaller penetration resistance.
2. The measured q_{ball} resistances more affected than T-bar shape in soft Batu Pahat clay because the ball shape is more sensitive than T-bar shape
3. The ball and T-bar penetration resistance are found close to similar. This finding implies that the balls and T-bar would the projected area close to each other.

4. The effectiveness rate of penetration on soft soil Batu Pahat when using T-bar shape especially between 5mm/s and 20 mm/s but less influence in high rate of penetration 40 mm/s the qt-bar 20 and qt-bar 40 they are quite similar.
5. It is found that the relationship between the rate of penetration and tip resistance is close similar when exceeds 20 mm./s

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