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PREDICTION OF SOIL SETTLEMENT BASED ON CONSTANT PLASTIC INDEX METHOD

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ABSTRACT: The development of Constant Plastic Index (CPI) method is an approach model based on the theory of consolidation. The objective behind the development CPI method is to predicts critical state settlement whereby CPI is to achieved secondary settlement and reduced time of consolidation. The development CPI has been derived base on the ultimate soil settlement where soils are classified accordingly using initial void ratio, final void ratio and thickness of soil layers. The linear and non linear soil was developed by the relationship between an exponential stress - void ratio and the parabolic permeability – void ratio. The external forces is normally consolidated soil layers and develop Stratum index factor (SIF) and Void ratio function(VRF) which is composed of such a soil varies non- linearly in deposition. Development of CPI will used to predicts critical state settlement, using Eurelian method By combination of these elements, the Potential Instability of settlement was develop and integrate CS- Rating makes concerted effort to produce CS- statement guidelines and better design strategy for geo - mechanics engineer to involve in soil development settlement analysis. Finally, modification of CPI method can be determine soil settlement by using CS- Rating.

Keywords: Constant Plastic Index, Void Ratio Function and Stratum Index factors

1. INTRODUCTION

This research is about development of Constant Plastic Index (CPI) method on Soft Ground Soil (SGS) and it is observed in a cohesive soil [1.2] SGS is a mixture of fragmented organic and massive erosion material formed in wetland and river mouth .SGS is partially or total decomposed remain of alluvium soil, dead plants which have accumulated under water for ten to thousands of year. It is generally found in thick layers in Figure 1.

limited areas, has show low shear strength and high compressive deformation which often result in difficulties when construction work is under taken on the deposit. CPI describes the expansion of consolidation theory using ultimate soil settlement, in which approximately varies 50m depth. The collection of undisturbed soil sample overlies original soft layer in the coastal area composed of soft marine clay with high water content and high compressibility.

The main objectives of the research were as follows:

a. To develop of Constant Plastic Index (CPI) method based on Consolidation Theory and To Predicts the settlement based on CPI method.

b. To analysis the Potential Instability (PI) using Eurelian projection method.

c. To integrate the CS-Rating for redicting soil settlement.

2. BACKGROUND

Malaysia has a total area of about 330,000 square kilometer. The total length of road network is about 61,000km and about 30% area in soft ground .Most of the soft ground are found on the costal lowlands and form a corridor parceling the

Undisturbed soil sample was obtained from: Tanjung Karang, Klang, Pulau Indah, Selangor, Bagan Datoh, Perak, Tanjung Bin,Johor, Lumut, Perak, Sabak Bernam, Selangor, Pulau Bunting, Yan Kedah, Teluk Panglima Garang,Selangor, Carey Island,Selangor. (Fig.1).

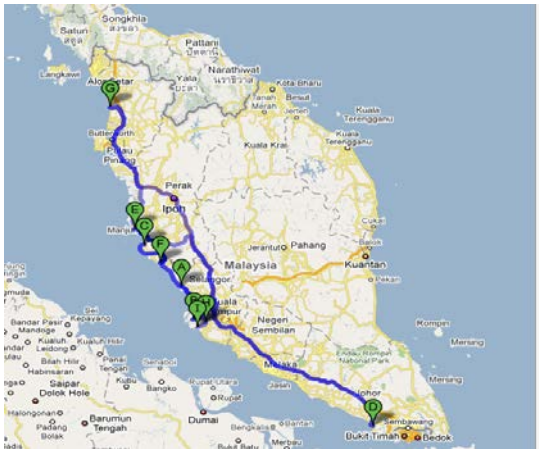

Fig. 1 Map depicting study sites chosen in the present investigation

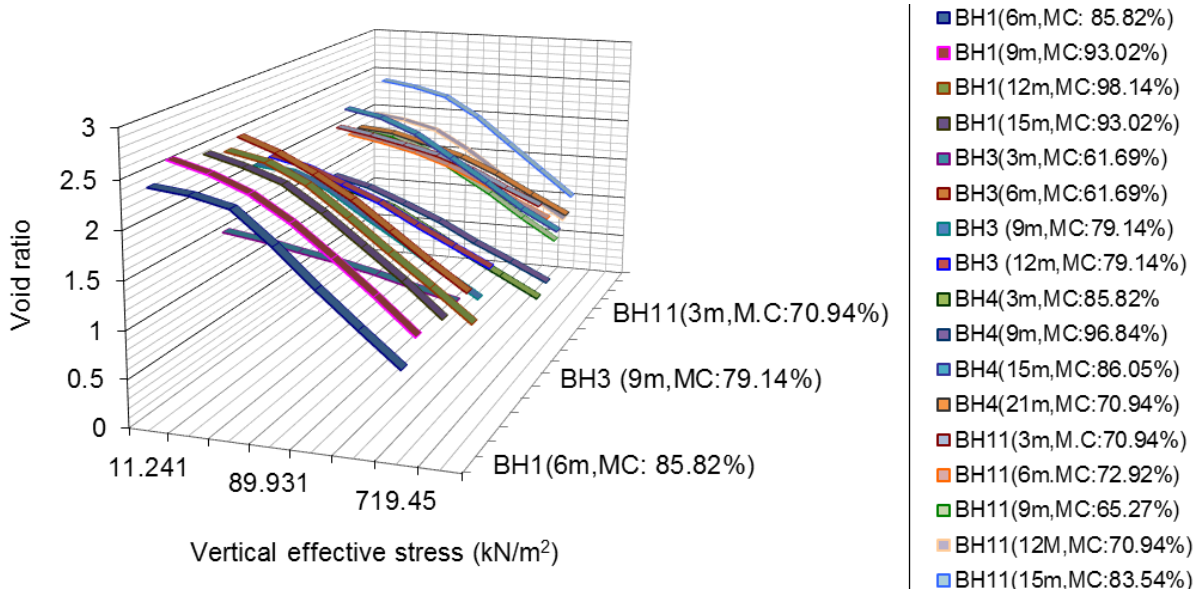

Fig. 2 Void ratio versus vertical effective stress

3. PROBLEM STATEMENT

This study is focused to development Constant plastic index method through consolidation theory on selected consolidation parameter .But there are some boundary limit on the Consolidation theory, because factors influencing the occurrences of settlement failure vary greatly depending on the characteristic coordinate on time and space of the soil. [4]. One of the limits in this research is the moving boundary pertaining in Fig.2 to the compression behavior, void ratio characteristics, and properties of cohesive soil in Eurelian method. Another limit is the fix boundary pertaining to the Langrangian coordinate.

4. SCOPE OF WORKS

A study was focused on the development for Constant Plastic Index (CPI) Method. The main focused of this research is to predicts soil settlement based on CPI parameter which will assist geological engineers to evaluate settlement. The Constant Plastic Index (CPI) are based on boundary transfer, and consolidation of soil layer. To used development CPI and analysis the Potential Instability(PI) and to integrate the CS-Rating for predicting Eurelian soil settlement .

5. LITERATURE REVIEW

5.1 Settlement Issues

There are many soil settlement or subsidence failures being report in the world [5][3]. Most of these failures are triggered by prolonged intensive rainfall. Rain water infiltrates into the soft soil and reduce the soil matric and the strength of soil. Many research [5] [6] found that the rainfall almost 13 to 20 times as much water is in the ground as is available on the surface. When withdrawals exceed recharge, the water table drops. This may result in subsidence of the ground surface, that is, a lowering of the ground surface from the voids because of reduced amount of groundwater cause of soil settlement. As example, consider Eloy, a town in Central Arizona, where land has subsided 10 feet in the last 30 years from groundwater overdraft[5]. As much as a 30 feet drop has occurred in south central California. Along with the subsidence in Arizona, large fissure 25 feet wide and 50 feet deep has been measured. Subsidence in Houston area has caused structural damages and damage to sewers and other drainage system. On May 11, 1981, a sinkhole 37.5 meters deep and 120 meters wide appeared in WinterPark, Florida, swallowing a house, six car, a camper van and a part of swimming pool. In Malaysia, [6] soft ground areas are also found in North-South Expressway and several other states like South Johore and Kelang – Sabak Bernam area cause a million ringgit to improve soil treatment cause of settlement. The understanding of the possible modes of failure is important to prediction soil settlement. The mode of possible failures depend on the influence of the consolidation process and reduced ground waters condition. The presence and movement of ground water also could affect soil settlement instability by generating seepage

force from ground water flow towards the ground surface..

6. METHODOLOGY

The program was initiated by used of the [7][8][16][17] equation to model the degree of consolidation curve for a given soil . This was quickly extended to encompass the effect of Constant plastic Index (CPI) and the coordinate – x and y between soil layer.

Following this is 5 item and 2 step of the procedure to determination soil settlement.

1) Develop Constant Plastic Index Based on Consolidation soil and determine the average degree of consolidation(CPI) [6] and degree of settlement (SIF) using Constant plastic index (CPI) and Stratum index factor.

2) Determine the primary settlement (Sp(oed)) using Skempton-Bjerrum [10] modification for consolidation settlement (1957) and primary settlement using development Constant plastic index (Sp(cpi)). Settlement versus CS Rating are presented in Table 2. 3) Determine the thickness of the layer (H) Calculate the.consolidation settlement St (Langrangian) as Lagrangian settlement

St (Langrangian I) = Ucpi x Sp(cpi)

Step 1

4) To develop Eurelian ground settlement, commonly used average of tendency for ungrouped data. Computation of the mean can be represented as population mean or sample mean for selected sites.

5) To Calculate the Eurelian consolidation settlement St (Eurelian)

S.(Eurelian) = E(Strain) (degree of settlement) (H)(depth thickness)

Step 2

Table 2 Settlement versus CS Rating

CS- Rating	Potential stability (PI)	CS- Statement	Suggestion Works
Rating 1 =3.64exp(-.17Rating) S rating <0.5	YES (Critical state) Tg Bin site . Load Test	High Risk . Settlement are expected to fail at any time and the failures are. Under consolidated soil	eed further URGENTinvestigation and urgent remedial work has to be done. The remedial work is suggested Soil Treatment (soil replacement, vertical rain , Stone coloum . Sand Coloum), Vacum Consolidation and for high rise building need Piling
Rating1 0.5 <CS Rating <2.2	YES (Critical State)	Medium Risk	o repair work but it suggested , resurface and water removed ,check drainage ystemThe remedial work is suggested Soil Treatment (Vertical drain , Stone bloum . Sand Coloum), Vacum Consolidation and for high rise building need piling
Rating 1 Cs- Rating >2.2	YES (Critical State)	Low risk	resurface and check drainage system
Rating 2 =3.547exp(-.67Rating) CS Rating<0.5	YES(Critical state)	High Risk . Settlement are expected to fail at any time and the failures are. Under consolidated soil	Need urgent further investigation and urgent remedial work has to be done. The remedial work is suggested Soil Treatment (Vertical drain , Stone bloum . Sand Coloum), Vacum Consolidation and for high rise building need Piling
Rating 2 .5<Cs rating <2.2	Yes critical state .	Medium Risk	To repair work but it suggested , resurface and check drainage systemThe remedial work is suggested Soil Treatment (Vertical drain , Stone coloum . Sand Coloum), Vacum Consolidation and for high rise building need piling
Rating 2 Cs- Rating >2.2	YES (Critical State)	Low risk	resurface and check drainage system

7. ANALYSIS

From Table 1 analyses, Development CPI method can predicts the conditions of the settlement. The level of Eurelian settlement can be determine by combination of two major statement. Statement no 1: YES for Critical state no 2: No for Steady state. From the CS- statement, the CS-System can predict the condition of Eurelian settlement.

Before any prediction can be done on Eurelian settlement, the CS system need the risk value and the CS rating will suggest the soil improvement. Soil improvement will increased the

consolidation due to achievement steady state and secondary settlement.

For example, if critical state and PI is YES, then 0.5 < CS rating < 2.2, the rate of settlement more than 0.3 m will give the critical thinking to predict settlement. This means that the soil surface needs further investigation and remedial work has to be done. The next example is for the Critical state [9] and PI is YES , then CS rating < 0.5 mean the 0.03m to offer its suggestions were produced through CS- Rating. CS –rating > 2.2 increasing consolidation due to steady state and shown in Fig.3 below:

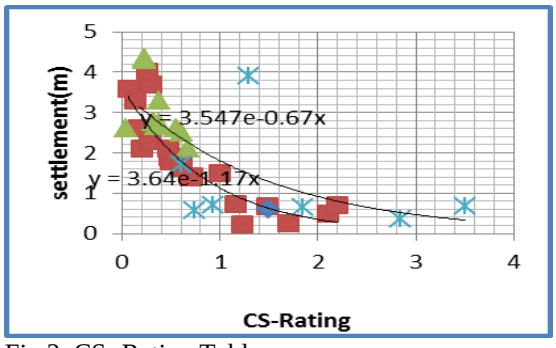

Fig.3 CS- Rating Table

No soil improvement work be done. Through analysis, it was agreed that the boundary movement of Eurelian Method that applicable by time and space. To offer its suggestion would steady state PI is NO. The expected situation would be no risk to settle either subsidence or heave.

Based on the development of Constant Plastic Index (CPI) method, the evaluation of void ratio function (F(e)) can derived Stratum Index Factors (SIF). The CPI method, evaluation of void ratio function F(e)) and Stratum index factors SIF can be summarized as follows:

Table 2 CS – rating versus settlement suggestion.

There are one type of analysis that will be dealt with in this item.

(a) Settlement versus CS-Rating

In Table 2 CS- settlement versus CS – Rating is plotted based on Chi-square Test and extreme degree of freedom (df) is cumulative distribution function for appropriate df give at least as extreme value from 1 is given p value. CS statement suggestion two curve based on degree of freedom. Between two curves is cumulative differential rate of settlement.

8. INDIVIDUAL RATING

The individual rating is the risk rating assigned to each Eurelian settlement based on their presence and condition at consolidation process. The weight of the individual rating 0.1 and 2 for the selected parameters are used for the risk rating calculation. The rating for the each parameter 0, 1 and 2, are depending on the level of risk that was identified based on degree of freedom (df) on the analysis Chi square test. Rating 0 for no risk , which means that volume change of soil F(e) = 1+e present or in active or insignificant or the level of risk is low. Rating 1 for contributory or medium risk, which means the degree of freedom (df) parameter is present and the level of risk is moderate. Rating 2 for high risk, which means that the df parameters highly contribute to settlement instability. The rating 0, 1 and 2 are summary Table The graph of CS-Rating versus Settlement is plotted in Table 2. Based on the graph, the level of risk in Table 2 was used to suggest level of Geohazard risk.

The lower CS--Rating, the more potential of soil to settle or fail. To finalize the potential failure or the degree of dangerous, the CS need the input of Potential Instability Statement (PI). Through these two values, CS statement can predict the level of dangerous of the settlement. The next step is for the CS statement to give suggestion on what to be done. The rules that are used by the CS to offer its suggestions were produced through Eurelian Method. The CS-System table is presented in Table 2. Through Chi square Test analysis, it was agreed that the boundary movement of Eurelian Method that applicable by time and space for Rating 1- CS-Rating is < 0.5 and Rating 2, CS Rating <0.5 and PI is YES, then the CS statement will give the prediction as High risk. Rating 1, 0.5 < CS-Rating is <2.2 and Rating 2, 0.5 < CS Rating >2.2 and PI is YES, then the CS statement will give the prediction as Medium risk. Rating 1, CS-Rating >2.2, and Rating 2, CS-Rating >2.2 and PI is YES, then the CS statement will give the prediction as Low risk .Rating 0, and PI is NO, then the CS statement will give the predictions as No risk.

The failure is not expected to happen immediately but will have a potential to happen if there is some other activity such as heavy rainfall. The category 4 is high risk, which means that the surface is highly potential to failure and the degree of failure is geo-hazardous.

The division between categories, No risk , Low risk, Medium risk and high risk is based on the risk geo- hazard rating, CS – Rating, and Potential instability analysis is tabulated in Table 2. The stability of individual settlement is controlled by the local Geomechanics setting condition [12], the soft ground climate change [13], local ground level water conditions [15] and also by the filling technique and also the height of embankment [14]. The identification of

surface that are potential to failure is the main goal in the prediction of settlement. The next is on the remedial works.

The potential instability of each settlement was investigated using Eurelian method with two statement. 1) YES if critical state and 2) NO, if steady state. For the Potential Instability Statement YES means that the surface layer are potential to settle like subsidence, hole or heave. While statement NO when no indication of potential failure.

9. CONCLUSION

It is found that the average degree of consolidation in critical state. CS – Statement in Table 1 is a model to process of human reasoning to develop consolidation due to achieved steady state condition, and it cannot develop with other research (eg. LKS, Hardin, Jamliolkowski, Malanowista). CS – Rating is increased due to slower settlement or secondary settlement. Settlement is increased due to increased Stratum index factor. Rating 2 is higher rate of settlement than Rating 1.

In the completion of the settlement evaluation process in Table 1, the development of CPI was integrated the major Potential Instability Statement (CS) . The CS settlement was divided into two categories : 1 . Yes to settle for critical state case or No to settle - for steady state case.

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