COMPARISON OF BACK ANALYSIS AND MEASURED LATERAL DISPLACEMENT OF CANTILEVER DIAPHRAGM WALL

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T O MY DEAR HUSBAND AND FAMILY

ABSTRACT

This study is aimed to evaluate the performance of a cantilever diaphragm wall earth retaining system, constructed by staged excavation. The actual performance extracted from geotechnical instrument is compared with the numerical method. The numerical method is using Soil Hardening model. The simulation of the computer analysis has been carried out using different soil stiffness parameter which have been correlated from 2000N, 2500N, 3000N and 3500N values (with N is the Standard Penetration Test values). The results obtained had been used to compare with the actual performance of the field data. From the results of the finite element analysis, the obtained lateral displacement profile is reasonably in close agreement when compared to the instrumentation profile. Thus the soil stiffness parameters (E_{50}^{ref} , E_{oed}^{ref}, E_{ur}^{ref}) which have been used to correlate based on 3500N values are suitable for the soil at the site of Kenny Hill formation, analysed in this project. The instrumentation data and the analyses have yielded very useful information for deep basement construction in terms of the selection of the soil parameters.

ABSTRAK

Kajian ini adalah bertujuan untuk menilai prestasi sistem tembok penahan tanah *diaphragm* kantilever dalam pembinaan pengorekan tanah secara berperingkat. Prestasi sebenar tembok yang di perolehi dari alatan instrumentasi geoteknikal akan di bandingkan dengan cara numerikal. Cara numerikal tersebut adalah mengunakan model *Hardening soil model.* Kekuatan tanah yang di perbandingkani dengan nilai 2000N, 2500 N, 3000N dan 3500N (dimana N adalah nilai dari Standard Penetration Test) disimulasi dengan mengunakan computer. Keputusannya digunakan untuk membuat perbandingan dengan prestasi sebenar yang diperolehi dari data tapak. Keputusan dari simulasi komputer , menghasilkan pergerakan tembok adalah menepati pergerakkan jika dibandingkan dengan profil instrumentasi. Dengan itu parameter kekuatan tanah (E_{50}^{ref} , E_{oed}^{ref} , E_{ur}^{ref}) dimana perbandingkan 3500N adalah bersesuaian untuk tanah *Kenny Hill formation.*. Data dari instrumentasi dan analisis telah menghasilkan maklumat penting dalam pemilihan parameter tanah untuk kerja pembinaan basemen.

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CHAPTER 1

INTRODUCTION

1.1 Background of Problem

The most cost effective and practical method to support an excavation is to slope back the sides of the excavation. The design requires only the soil properties of the excavated area so as to determine the angle of reponse. The concept of the design requires wider space for the proposed slope and the excavation may not be deep. Another setback will be the excavated area is near to the adjacent building. The subject of the construction for deep excavation become more complicated, when there is no adequate space, slope cannot be accommodated and therefore an earth retaining system is the solution. The three basic types of earth retaining systems are cantilevered, braced or tied-back system.

The design of the retaining wall system can be from a simple empirical method towards a more complicated complex computer analysis. Whatever the method, the design aspects are the stresses, loads related to the wall system and the effect of construction method. Other than those design methods, the designer past experience is significant too. The designer must be equipped with the subject literature, aided with the geotechnical journals and texts for him to apply an appropriate solution from many options to excavation support problem.

However in the increasingly competitive environment where “value engineering” is required followed by the reluctance of the client to invest in “geotechnical cost”, the designer is required to produce a design with minimal cost. Whatever the preferred solution from the many available solutions, the risks involved have to be evaluated and any failures of the retaining wall must not happened. The

preferred solution must therefore produce safe and economical design taking all aspects into consideration.

1.2 Statement of Problem

The occurrence of ground displacement due to excavation works in deep excavation is based on many factors such as the stratigraphy, soil properties, lateral earth pressure, the method of constructions, contractual matters, soil loads, water table, seepage problem and workmanship. These factors need to be considered in the design procedure to understand the ground response due to excavation. Related to the deep excavation, other important aspect is the evaluation of the foundation for the adjacent properties and the effects of the excavation on the serviceability of the adjacent structures.

The subsoil stratigraphy is generally obtained by auger deep boring supported with Standard Penetration Test result from borehole. With the data taken from the multiple boreholes and then drawn in the geometry, can lead to understand the soil stratigraphy. The soil properties such as friction angle, cohesive intercept, and poisson's ratio are required for any design method of earth retaining structure whether using numerical or simplified method.

This data used in the design process is confirmed by the instrumentation monitoring on the behavior of the earth retaining system. Both the predicted and actual behavior of the retaining system must be the same during/and at end of the construction period. The need to monitor the behavior of the earth retaining wall in conjunction with the stage of excavation which is required to evaluate the actual behavior is similar to the predicted or as designed. If otherwise immediate action is necessary to resolve the problem cause by the unexpected behavior of the supported soil. This may be due to the construction nearby causing the change in the water level or wrong interpretation of soil data.

This study is aimed to evaluating the performance of a cantilever diaphragm wall earth retaining system, constructed by staged excavation. The actual

performance extracted from geotechnical instrument will be compared with the numerical method. The numerical method is using Soil Hardening model.

1.3 Objective of the Study

The objectives of the study are as follows:

i) To determine soil properties and the standard penetration test (SPT-N) values of the soil layers at site location.

ii) To determine the correlation between the soil stiffness parameter with the field SPT-N values by comparing the monitoring measurement results with the values obtained from the finite element analysis result using Hardening Soil model for the lateral displacement of cantilever diaphragm wall.

iii) To determine the wall deflection using the previous researchers correlation of soil stiffness and SPT-N values.

1.4 Scope and Limitation

This case study has been conducted on particular project, which is represent by a development with a 7 m depth basement at a site somewhere in Kuala Lumpur. The detail of the subsoil parameters, existing and proposed soil platform, the stages of excavation, the retaining wall system and the on-site instrumentation data has been used in the case study. The analysis has been carried out with numerical method using Finite Element Analysis by the aid of computer program (Plaxis). The lateral displacement results compare with the actual behaviour of the retaining wall system, taken from the instrumentation data. However, the instrumentation data used was for the horizontal deflection of the wall only. The limitation of using the Plaxis analysis is limited to Soil Hardening Model using the available soil data obtained from the available borehole results.

1.5 Significant of the Study

This study will be very useful to geotechnical engineers to be used as reference for analyzing the stability of the retaining wall system with respect to the lateral movement created during construction. The outcome of the study will show that the design and construction method of the project will be used as guidance to similar condition of other construction sites for prediction of horizontal movement. The soil parameter for the individual soil type can be used as a guide to all designers with similar condition. The design model is also significant whereby it can be used for similar condition.

REFERENCES

Chang Yu Ou (2006) *Deep Excavation, Theory and Practice*. Taylor and Francis/Balkema.

Raj Jalla (1999)) *Basement Wall Design for Geotechnical Aspects*. Journal of Architectural Engineering. Pp. 89-91.

Daniel C.Brahana, William M Tanner, E.I.T., and Larry D. Mullins (2007). *Deflection and earth pressure measurements of an anchored concrete shoring wall*. Seventh International Symposium on Field Measurements in Geomechanics.

Karki R (2006) *Effects of Deep Excavations on Circular Tunnels in Fine-Grained Soils.* A thesis submitted to the Department of Civil and Geological Engineering , University of Saskatchewan, Saskatoon, S. K. ,Canada

Liew S.S (2008). *Case Studies of Support of Open Excavation and Distressed Retaining Wall in Malaysia*. Seminar on Excavation and Retaining Wall.

Freiseder M.G. and Schweiger H.F. (1999). *Performance of the hardening soil model for a deep excavation*. Beyond 2000 in computational geotechnics- 10 years of plaxis international @ 1999 Balkema, Rottendam.Pp 263-270

Tan S. A .(2007) *Advances and Impact of Numerical Modeling on Excavation Works in Singapore*. Development, Advancement and Achievement of Geotechnical Engineering in Southeast Asia, 40th Anniversary Commemorative of the Southeast Asian Goetechnical Society. Pp 233-242

Liew S.S and Gan S.J. (2007) *Back Analyses and Performance of Semi Top-Down Basement Excavation in Sandy Alluvial Deposits.* 16 th South-East Asian Geotechnical Conference. Pp. 833-837

James W.C.Sze and Albert N.L.Ho (2008). *An Account of Deep Excavation Using Steelwork in Hong Kong.* Seminar on Excavation and Retaining wall (2008).

Yee Y.W. and Chua C.G.(2008). *Case Studies: Deep Soil Mixing in Excavation.* Seminar on Excavation and Retaining Wall (2008).

Bowles J.E. (1998) *Foundation. Analysis and Design.* Fourth Edition. Mc Graw-Hill International Editions.

Law K.H. (2008). *Performance of Multi-propped Deep Excavation in Kenny Hill Formation*. A thesis for Universiti Teknologi Malaysia. Unpublished.

Burd H.J.(1999) *The History of Plaxis* .Beyond 2000 in Computational Geotechnics-10 years of Plaxis International. A.A. Balkema/Rotterdam/Brookfield

Brinkgrave R.B.J. (2005) . Plaxis 2D. Tutorial Manual Version 9.0

Macnab A (2002). *Earth Rretention Systems Handbook*. M.C. Graw Hill Handbook.