BEARING CAPACITY, COMPARISON OF RESULTS FROM PLAXIS 2D AND EMPIRICAL MODEL

HONG PUAN YEE

A project report submitted in partial fulfilment of
the requirements for the award of the degree of
Master of Engineering (Geotechnics)

FACULTY OF CIVIL ENGINEERING
UNIVERSITI TECHNOLOGY MALAYSIA

MAY 2017

ACKNOWLEDGEMENT

This technical report has been written as a part of the Master in Geotechnics program at Universiti Teknologi Malaysia (UTM), Skudai, Johor, and was written over a course of 32 weeks from September 2016 to May 2017.

I would like to express my gratitude to my advisor, Associate Professor Dr. Nazri Ali, for his worthy guidance, priceless advice, well-built support, suggestions and encouragement throughout the study.

I would like to express profound appreciation to my current company, GCU Consultants Sdn Bhd for providing me information and data for my study.

Sincere appreciation goes to UTM for providing me admission to pursue master degree in Geotechnics.

Last but not the least, I would like to express deep gratitude to my parents for their love, care and support during my study in UTM.

ABSTRACT

Shallow foundations are commonly used to support structures of all in sizes in order to safely transmit the structural load to the ground without exceeding the bearing capacity of the ground and causing excessive settlement. They are typically embedded up to a few meters into the soil profile. While designing shallow foundations, two requirements need to be satisfied, which the first one is complete failure of the foundation must be avoided with adequate margin of bearing capacity and settlement should be within the designed limits that can be tolerated by superstructure. The bearing capacity of foundation is typically analysed using Terzaghi model, Meyerhof model, Hansen model or Vesic model. In this paper, a comparison of empirical analysis is presented by using Terzaghi model, Meyerhof model, Hansen model and Vesic model. The result of these models is compared by using numerical analysis by using Plaxis 2D. The paper includes a discussion of the differential between each model. The soil profiles and parameters used in the analysis were based on either in situ tests or laboratory tests. The case study was based on soil from a site from Klang Valley. Three cases with different of friction angle of the soil were used to analyse the bearing capacity of the strip footing. Meanwhile for the settlement analysis, three different depth of the footing were used. This is because the settlement of the footing will majorly affect by the depth of the footing. The results of the bearing capacity and settlement were further verify by the result from PLAXIS 2D.

ABSTRAK

Asas cetek biasa digunakan untuk menyokong struktur dalam saiz yang berbezaan untuk memindahkan beban struktur bangunan ke lapisan tanah dibawahnya dengan selamat tanpa melebihi nilai beban per keupayaan galas tanah dan menyebabkan penempatan yang berlebihan. Asas cetek biasanya ditanam sehingga beberapa meter ke dalam profil tanah. Untuk merekabentukkan asas cetek, dua keperluan perlu dipenuhi, yang pertama adalah kegagalan penuh asas cetek itu mesti dielakkan dengan margin yang mencukupi nilai beban per keupayaan galas tanah dan penempatan hendaklah tidak melebihi had yang boleh diterima oleh struktur. Nilai beban per keupayaan galas tanah biasanya dianalisis dengan menggunakan model Terzaghi, model Meyerhof, model Hansen atau model Vesic. Dalam tesis ini, perbandingan analisis empirikal telah dibandingkan dengan menggunakan model Terzaghi, model Meyerhof, model Hansen dan model Vesic. Keputusan daripada model-model ini telah dibandingkan dengan menggunakan analisis berangka dengan menggunakan Plaxis 2D. Tesis ini termasuk perbincangan tentang perbezaan di antara setiap model. Profil tanah dan parameter yang digunakan dalam analisis ini adalah berdasarkan sama ada dalam ujian situ atau ujian makmal. Kajian kes ini adalah berdasarkan tanah dari salah satu tapak di Lembah Klang. Tiga kes dengan sudut geseran tanah yang berbezaan telah digunakan untuk menganalisis nilai beban per keupayaan galas tanah asas jalur. Sementara itu, bagi analisis penempatan, tiga kedalaman yang berbezaan daripada asas jalur yang telah digunakan. Ini adalah kerana penempatan asas cetek biasanya akan dijejaskan oleh kedalamanya. Keputusan nilai beban per keupayaan galas tanah dan penyelesaian telah digesahkan dengan menggunakan keputusan dari PLAXIS 2D.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

B	-	Width of Footing
L	-	Length of Footing
D_f	-	Depth of Footing
z	-	Depth
q_u	-	Ultimate Bearing Capacity
c	-	Cohesion of Soil
q	-	Overburden Pressure
γ	-	Unit Weight of Soil
N_c, N_q, N_γ	-	Bearing Capacity Factors
ø	-	Friction Angle of Soil
λ_{cs}, λ_{qs} & $\lambda_{\gamma s}$	-	Shape Factor
λ_{cd}, λ_{qd} & $\lambda_{\gamma d}$	-	Depth Factor
λ_{ci}, λ_{qi} & $\lambda_{\gamma i}$	-	Inclination Factor
σ_z	-	Stress
I_R	-	Influence Factor
S_c	-	Settlement of Footing
m_v	-	Coefficient of Volume Compressibility
SPT	-	Standard Penetration Test
ABH	-	Bolehole
μ	-	Poisson Ratio of Soil
E	-	Modulus of Soil

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Back ground of the Study

The design of shallow foundation consists of two parts which is the ultimate bearing capacity of the soil under the foundation, and the allowable settlement that the footing can undergo without affecting the superstructure. The ultimate bearing capacity is the pressure that the soil under the foundation can take before the shear failure of the soil occurred. Meanwhile, the allowable settlement of the foundation cause by the loading of the superstructure and its self-weight should not exceed the tolerance limits of the stability and also the serviceability of the superstructure.

The bearing capacity of shallow foundation is usually calculated using empirical equations. The basic equation for the shallow foundation is first derivate from Terzaghi in year 1948 to determine the ultimate bearing capacity of shallow foundation. Terzaghi defined a foundation as a shallow foundation where the width of the footing, B is equal or less than the depth of the footing, D_f. Until the developed of general bearing capacity equation, there are many model can be used to design a simple shallow foundation, such like using Meyerhof model, Hansen model and Vesic model. Each of the model has different definition in the term of illustrates the

dimensionless correction factors, such as shape factor, depth factor and inclination factor.Hence, by using different of modal it will give a different value of bearing capacity

The finding of the different model can be carried out using either numerical analysis or actual site results. In this paper, a comparison is made between the bearing capacity resulted from Meyerhof, Hansen and Vesic model with the numerical analysis.

The purpose of this research is to find out which empirical model is more conservative and more reliable. Most of the research mentioned that Terzaghi model was the most conservative, however it is believed that Hansen and Vesic model will be more reliable since more factors had been consider in the design criteria such as shape factor, depth factor and inclination factor. Besides that, the comparison of determine the stress distribution method of different model will also been study in this research. By comparing both the approximate 2 to 1 distribution method and Boussinesq's solution, the reliable of the results will be finalizing using numerical analysis.

1.2 Problem Statement

Terzaghi's bearing capacity equation has been used in the design of numerous shallow foundations throughout the world and is widely been use still nowadays. However, they are now considered by many to be conservative as factors that affect bearing capacity, such as inclined loading, foundation depth, the shear resistance of the soil above the foundation and etc, which all of these factors were not taken consideration into the calculation.

1.3 Objectives of Study

i. To calculate and compare the differential of bearing capacity result for each of the empirical modal developed by Terzaghi, Meyerhof, Hansen and Vesic.
ii. To calculate and compare the differential of stress distribution results by using Boussinesq method and two to one distribution method.
iii. To validate the reliability of the bearing capacity empirical result with numerical model.
iv. To check the reliability of stress distribution calculation method with numerical model.

1.4 Scopes of Study

The objective of this report is to provide the reliable design methodology for the shallow foundation, which included the works as below:

i. Initial calculation by using various of empirical model
ii. Analyse the result of empirical design model using numerical model with Plaxis 2D

REFERENCES

Braja, M. (2009) Terzaghi's Bearing Capacity Theory. Shallow Foundations Bearing Capacity and Settlement, pp 11.

Johnson, K., Christensen, N., Sivakugan, N., & Karunasena, W. Numerical Prediction for Federal Highway Administration. Simulating the Response of Shallow Foundations using Finite Element Modelling, pp 4-5.

Rostami, V., & Ghazavi, M. (2015) Analytical Solution for Calculation of Bearing Capacity of Shallow Foundations On Geogrid-Reinforced Sand Slope. Transactions of Civil Engineering, Vol. 39, No. C1, pp 167-182.

Roy, E., & Jiunnren, L. (2003) Stress Distribution. Advanced Soil Mechanics, pp 134-135.

Bjorn, S, K., & Niels, M. (2013) Method of Investigation. Bearing Capacity, Comparison of Results from FEM and DS/EN 1997-1 DK NA 2013, pp 578-580.

Brenousky, J, S. A Computational Modelling Approach. Modelling the Interaction between Structure and Soil for Shallow Foundation, pp13-15.

Raviteja, K., Umashankar, B., Ramu, K., & Dayakar, B. (2014) Bearing Capacity of a Strip Footing Resting on Treated and Untreated Soils. Proceeding of Indian Geotechnical Conference IGC, pp3-5.

Mohd, R, T., & Enas, B, A. (2013) Numerical and Experimental Evaluation of Bearing Capacity Factor of Strip Footing on Sand Slopes. International Journal of Physical Sciences, pp2-3.

Santosh, K. (2013) Bearing Capacity of Shallow Foundation. Backcalculation of Plate Loading Tests using Plaxis 2D and the Hardening Soil Model, pp28-38.

Alan, J, L., & Don, J, D. (1995) Estimating Settlement from In Situ Test Result. Settlement of Shallow Foundations on Granular Soils, pp56-59.

Stenfan, V, B. (2014) The Inclination and Shape Factors for the Bearing Capacity of Footings. The Japanese Geotechnical Society, pp 2-4.

Rostami, V., & Ghazavi, M. (2015) Analytical Solution for Calculation of Bearing Capacity of Shallow Foundations on Geogrid-Reinforced Sand Slope. IJST, Transactions of Civil Engineering, Vol. 39, pp167-182.

Mona, A., Ali, A, M., & Ali, R, M., Discrete Element Model. Three Dimensional Bearing Capacity of Shallow Foundations Adjacent to Slopes using Discrete Element Method, pp 3-5.

Carlos, A, F. (2004) Experimental Values of the Angle.Ultimate Bearing Capacity of Shallow Foundations on Layered Soils, pp28-29.

Johnson, K., Christensen, M., Sivakugan, N., & Karunasena, W. Numerical Model. Simulating the Response of Shallow Foundations using Finite Element Modelling, pp2-5.