A COMPARISON OF PILE PERFORMANCE BASE ON STATIC FORMULAS AND DYNAMIC LOAD TEST

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ABSTRACT

Since the early of pile static formula suggested by Meyerhof (1956) up until now, several pile design method is being proposed. Between one method and another, result differences are still questionable. This study is conducted base on driven pile 300 mm diameter spun pile constructed in Malaysia on sand or fine soil. This is to determine the differences between several pile design methods by Meyerhof (1976), Janbu (1976), Vesic (1977), Coyle and Castello (1981), α method (1985) and λ method (1972) with the End-bearing capacity and Skin Resistance capacity value from dynamic load test using Pile Driving Analyzer (PDA). All the design method is also analyzed by using soil friction angle correlation by Schmertmann (1975), Peck, Hanson and Thornburn (1974) and Hatanaka and Uchida (1996). From analysis it can be found that Meyerhof, Coyle and Castello, and λ method are the most conservative which its value lower or almost near the PDA value. Then follow by Janbu method and α method which its value almost near PDA or slightly above it. Vesic method is found to be very unconservative which it value well above PDA value. From this study it can be conclude that it is recommended to use either Meyerhof or Janbu Method for estimating end-bearing capacity in sand and silt. For skin resistance in sand it recommended using Meyerhof method. Finally for estimating skin resistance in clayed soil it is recommended to use λ method.

ABSTRAK

Sejak daripada awal kewujudan formula static cerucuk yang telah dicadangkan oleh Meyerhof (1956), beberapa formula rekabentuk cerucuk telah dicadangkan oleh beberapa individu yang lain. Walaubagaimanapun perbezaan rekabentuk antara beberapa formula ini masih lagi menjadi tanda tanya. Kajian ini dijalankan berdasarkan cerucuk kelompang bersaiz 300 mm diameter yang telah ditanam di atas tanah berbutir halus dan berpasir di Malaysia. Kajian ini adalah untuk mengkaji perbezaan keupayaan galas dan geseran kulit cerucuk antara beberapa kaedah rekabentuk cerucuk oleh Meyerhof (1976), Janbu (1976), Vesic (1977), Coyle dan Castello (1981), kaedah α (1985) dan kaedah λ (1972) dengan keupayaan cerucuk yang diperolehi daripada ujian beban cerucuk menggunakan *Pile Driving Analyzer* (PDA). Kesemua kaedah rekabentuk turut dianalisis menggunakan sekaitan sudut geseran tanah oleh Schmertmann (1975), Peck, Hanson dan Thornburn (1974), dan Hatanaka dan Uchida (1996). Daripada analysis, dapat dirumuskan bahawa kaedah λ, Coyle dan Castello, dan Meyerhof merupakan kaedah yang paling konsevatif kerana mempunyai nilai keupayaan yang rendah atau hampir dengan nilai PDA. Ini diikuti oleh kaedah α dan kaedah Janbu yang mempunyai nilai yang hampir atau lebih sedikit daripada nilai PDA. Kaedah Vesic didapati merupakan kaedah yang paling tidak konservatif kerana mempunyai nilai yang agak tinggi berbanding dengan nilai daripada PDA. Daripada kajian ini dapat disimpulkan bahawa kaedah Meyerhof dan Janbu merupakan kaedah paling sesuai bagi analisis keupayaan galas tanah pasir dan kelodak. Bagi analisis keupayaan geseran kulit cerucuk ditanam di tanah pasir, kaedah Meyerhof merupakan yang paling sesuai. Akhir sekali, kaedah λ merupakan kaedah yang dicadangkan bagi analysis keupayaan geseran kulit cerucuk ditanam di tanah liat.

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SYMBOLS

w	Soil moisture content
γ	Unit weight of soil
γ_{sat}	Unit weight of saturated soil
γ_w	Unit weight of water
c_u	Undrained shear strength
L	Pile penetration length
L'	Pile critical depth (for skin resistance analysis)
G_s	Specified gravity of soil
σ	Soil vertical effective stress / overburden pressure
P_a	Atmospheric pressure
D_r	Soil relative density
ϕ	Soil friction angle
D_{50}	Sieve size passing 50% in mm
δ	Soil-pile friction angle
I_{rr}	Reduced rigidity index for the soil

CHAPTER I

INTRODUCTION

1.1 Introduction

Pile foundations have been in use since prehistoric times. The Neolithic inhabitants of Switzerland drove wooden poles in the soft bottoms of shallow lakes 12,000 years ago and erected their homes on them (Sowers 1979). Venice was built on timber piles in the marshy delta of the Po River to protect early Italians from the invaders of Eastern Europe and at the same time enable them to be close to the sea and their source of livelihood. In Venezuela, the Indians lived in pile-supported huts in lagoons around the shores of Lake Maracaibo. Today, pile foundations serve the same purpose, to make it possible to build in areas where the soil conditions are unfavorable for shallow foundations.

Although it dates back to prehistoric lake villages, until late nineteenth century, the design of pile foundation was based entirely on experience or even divine providence. Modern literature on piles can be said to date from the publication of the *Engineering News* (later to become the *Engineering News-Record*) in 1893, pile- driving formula was proposed (Poulos, H.G. 1980).

Since this first attempt at a theoretical assessment of the capacity of a pile, a great volume of field experimental and empirical data on the performance of pile foundation has been published.

By now there is several design method can be use in pile design but only few is suitable use for practice. Although there is few of this design method, the value estimated different between one and another are still questionable. That which comes to the main interest of this study which method is suitable for a given condition.

In this study which entitles "A Comparison of Pile Performance Base on Static Formulas and Dynamic Load Test", the performance of pile on end-bearing capacity and skin resistance analysis will be study base on the Pile Driving Analysis (PDA) pile capacity value to be compared with several selected analysis method.

1.2 Objective

This study aim is to give a guideline for pile designer to choose which method is suitable for a certain type of soil properties and condition. There is four objective in this study that need to be achieve in order to conclude which pile static formula suitable for a given soil condition:

1. To estimate theoretical pile end-bearing capacity (Q_p) and skin resistance capacity (Q_s) for each study cases.

2. To compare theoretical pile end-bearing capacity (Q_p) and skin resistance capacity (Q_s) from various pile static formula with dynamic load test on each study cases.

3. To determine the relationship between pile end-bearing capacity (Q_p) and skin resistance capacity (Q_s) ratio ($Q_{(Theory)}/Q_{(PDA)}$), with effective vertical stress at the level of pile tip (σ') on each study cases.

4. To determine the relationship between pile end-bearing capacity (Q_p) and skin resistance capacity (Q_s) ratio ($Q_{(Theory)}/Q_{(PDA)}$), with soil friction angle (ϕ) on each study cases.

1.3 Research Scope

This research is base on the data obtain from Soil Investigation Report and Pile Load Test Report on construction Project in Malaysia. Only large displacement type of pile is consider in this studies because of the availability of data which can give a better analysis result. The type of pile selected for this research is limited to driven pile type 300 diameter spun pile. The load-carrying capacity of the pile point (Qp) and skin friction (Qs) data obtain from dynamic pile load test is using Pile Driving Analyzer (PDA) method.

The estimation of theoretical load-carrying capacity of the pile point (Q_p) is analyze using three type of method which are Meyerhof's Method (1976), Vesic's Method (1977), and Janbu's Method (1976). Whereas the skin friction (Qs) is analyzed using Meyerhof's Method (1976) and Coyle and Castello Method (1981) for sand and for clayey soils, analysis is using α Method (1985) and λ Method (1972). The selection of these analysis methods is base on the most preferable design method use in Malaysia pile design practice.

1.4 Importance of Study

This study importance because pile and soil interaction is not an easy knowledge to be fully understand, even from the very earliest pile formulation studies by Meyerhof (1956) up until now, still consider as an estimated value.

With the various pile static formula nowadays, the different between one method and another cause a lot of uncertainties which contributing higher safety factor. A higher safety factor in a design mean, a utilization of a larger pile cross section which laterally cause an unnecessary larger piling cost. At a worst case, a proposal of a vital project has to be turn down just because of the piling cost is unreasonable compare to the superstructure itself.

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