# ESTIMATION OF BASE CAPACITY FOR BORED PILE EMBEDDED IN HARD STRATUM

ANUM SYAHIRAH BINTI AHMAD MAZLAN

UNIVERSITI TEKNOLOGI MALAYSIA

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ANUM SYAHIRAH BINTI AHMAD MAZLAN

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*Dedicated to my family & friends,*

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# ABSTRACT

Based on current design practice, the base resistance of a pile often ignored which results to inadequate pile load design. Besides mobilising factor, the ignorance of base resistance may be due to uncertainties in effective cleaning of the boreholes. This paper represents determination of base capacity for bored pile towards hard stratum. Empirical equations and reviews related to ultimate base resistance from Standard Penetration Test (SPT) data results obtained from site investigation (SI). Results from several analysis have been evaluated by taking account of overburden pressure in the order to prove the existence of base capacity for bored pile at site. Aspect of construction for bored pile in hard stratum also presented together as it related to important matters towards base capacity and performance of the bored pile itself. Based on the result obtained, method by Meyerhof (1976) gives the best prediction of base capacity for hard stratum in Malaysia as the existance of base capacity itself cannot be ignored to get an adequate bore pile load design.

# ABSTRAK

Berdasarkan amalan reka bentuk arus, rintangan asas cerucuk yang sering diabaikan yang menyebabkan kepada kekurangan reka bentuk beban cerucuk. Selain menggerakkan faktor, kejahilan rintangan asas mungkin disebabkan oleh ketidaktentuan dalam pembersihan berkesan lubang gerudi. Kertas kerja ini mewakili penentuan keupayaan asas untuk cerucuk bosan terhadap lapisan keras. Persamaan empirikal dan ulasan yang berkaitan dengan rintangan asas utama dari Ujian Penusukan Piawai (SPT) Keputusan data yang diperoleh daripada penyiasatan tapak (SI). Keputusan dari beberapa analisis telah dinilai dengan mengambil kira tekanan tanggungan dalam perintah itu untuk membuktikan kewujudan kapasiti asas untuk cerucuk bosan di tapak. Aspek pembinaan cerucuk bosan dalam lapisan keras juga dibentangkan bersama-sama kerana ia berkaitan dengan perkara-perkara yang penting ke arah keupayaan asas dan prestasi cerucuk bosan sendiri. Berdasarkan keputusan yang diperolehi, kaedah oleh Meyerhof (1976) memberi ramalan yang terbaik keupayaan asas untuk lapisan keras di Malaysia kerana wujudnya kapasiti asas itu sendiri tidak boleh diabaikan untuk mendapatkan lubang cerucuk reka bentuk beban yang mencukupi.

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| | | |
|---|---|---|
| $Q_{ag}$ | - | Allowable geotechnical capacity |
| $Q_{su}$ | - | Ultimate shaft capacity |
| $Q_{bu}$ | - | Ultimate base capacity |
| $f_{su}$ | - | Unit shaft resistance for each layer |
| $f_{bu}$ | - | Unit base resistance for the bearing layer |
| $A_s$ | - | Pile shaft area |
| $A_b$ | - | Pile base area |
| $F_s$ | - | Partial Factor of Safety for Shaft Resistance |
| $F_b$ | - | Partial Factor of Safety for Base Resistance |
| $F_g$ | - | Global Factor of Safety for Total Resistance |
| $K_{su}$ | - | Ultimate unit shaft resistance of soil |
| $K_{bu}$ | - | Ultimate unit bearing resistance of soil |
| $\alpha$ | - | Adhesion factor |
| $s_u$ | - | Undrained shear strength |
| $K_{se}$ | - | Effective stress shaft resistance factor |
| $\sigma_v$ | - | Vertical effective stress |
| $\phi'$ | - | Effective angle of friction (degree) of soils |
| $N_c$ | - | Bearing capacity factor |
| $N_\gamma$ | - | Bearing capacity factor |
| $N_q$ | - | Bearing capacity factor |
| B | - | Pile diameter |
| D | - | Depth of pile base |
| $\beta$ | - | Shaft resistance factor for coarse grained soils |
| $q_b$ | - | End bearing capacity |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Shallow foundation are normally used where the soil close to the ground surface and up to the zone of significant stress possesses sufficient bearing strength to carry the superstructure load without causing distress to the superstructure due to settlement. However, where the top soil is either loose or soft or of a swelling type the load from the structure has to be transferred to deeper firm strata. The structural loads may be transferred to deeper firm strata by means of piles.

Piles are long slender columns either driven, bored or cast-in-situ. Driven piles are made of variety of materials such as concrete, steel, timber or else whereas cast-in-situ piles are concrete piles. They may be subjected to vertical or lateral loads or a combination of vertical and lateral loads. If the diameter of a bored cast-in-situ pile is greater than about 0.75m, it is sometimes called a drilled pier, drilled caisson or drilled shaft. The distinction made between a small diameter bored cast-in-situ pile and a larger one is just for the sake of design consideration.

Usually, pile foundation (or deep foundation) used when rock level are shallow enough for end bearing pile, lateral forces are relatively prominent, and the presence of expansive and collapsible soils at site. This type of foundation may also be founded at offshore areas which near the flowing water to avoid the problem due to erosion.

Bored pile (Figure 1.1) are commonly used in Malaysia as foundation to support heavily loaded structures such as high-rise building and bridges in view of its low noise, low vibration, and flexibility of sizes to suit different loading conditions and subsoil conditions. Such attributes are specially favoured in urban areas where strict restrictions with regards to noise and vibration are imposed by relevant authorities which restricted the use of other conventional piling system such as driven piles.

**Figure 1.1 :** Bored Pile

The end bearing resistance is often ignored in current design practice in Malaysia due to difficulty in obtaining proper and consistent base cleaning during construction of bored piles (Figure 1.2). Neglecting the end bearing resistance in design will result in inadequate pile load design. Crapps and Schmertmann (2002) suggested that accounting for end bearing resistance in design and using appropriate

construction and inspection techniques to ensure quality of base cleaning is a better approach than neglecting end-bearing resistance.

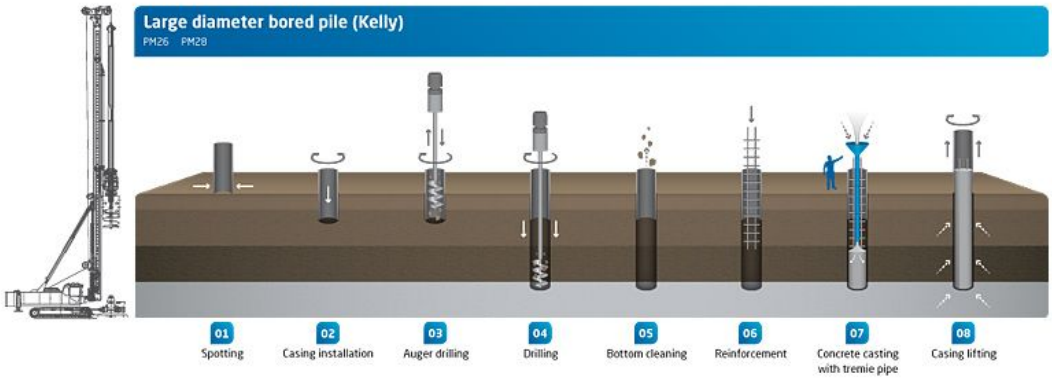


**Figure 1.2 :** Bored Pile Construction Stage

In most scenarios, base capacity of bored pile is usually being ignored due to uncertainties in effective cleaning of the boreholes. Unless for the case of dry hole and inspection of the base is possible, then base capacity can be considered with appropriate mobilising factor. In addition, base capacity concerns related to hand dug caisson. However, to determine an effective design of bored pile, base capacity must take into consideration.

## 1.2 Significance of Study

A few methods have been proposed for predicting the bearing resistance of bored piles. Of these different methods, empirical and semi-empirical relations have been used most widely. The method used by previous literature correlates the base resistance with respect to the consideration of it without ignoring the existence. However, there is still no such study conducted in Malaysia. It is uncertain how

many percentage of base capacity included in a bore pile load design which may be applicable for the current industry in Malaysia.

The significance of this study is to ensure the correlations by previous study adopted for design of end bearing resistance are satisfactory and in order to be implemented in Malaysia. This study will also provides better understanding towards consideration of base capacity in the design stage of a bored pile.

## 1.3 Objective of the Study

The aim of this study is to identify the consideration of base capacity towards bored pile. With the deal of base capacity, it is hope that the proper and economical design for bored pile can be carried out. Besides, the method of installation for bored pile also can be revised.

Other related objectives are as follows:

a. To analyze base capacity for bored pile embedded in hard stratum
b. To identify the percentage of base capacity for an adequate design of bored pile.
c. To compare the ultimate capacity of bored pile by the concern of base capacity.

## 1.4 Scope of the Study

The scope of works of this study includes some literature reviews on the relevant subject, data collections of insitu test and preliminary site investigation, and

analysis of base capacity for bored pile. The scope covers topics on bored pile, determination of its base capacity from Standard Penetration Test (SPT) N-value, and semi empirical calculations to get the reaction of bored pile towards hard stratum.

The scope does not cover the skin resistance, negative skin friction, and other types of deep foundation. The analysis used for determining base capacity is by using semi empirical equations. A site investigation report which contains factual sub-surface information and laboratory test results used for this study.

capacity itself towards total ultimate load of bored pile. The following recommendations are proposed for further studies:

1) More Standard Penetration Test (SPT) results are needed for this study to validate the design approaches which may suits to be adopted for bored pile design.
2) The other soil investigation works such as pile load test need to be considered to recognize the best method in order to get an adequate bored pile design.

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