Faculty of Engineering

ANALYSIS OF PILE GROUP

MENSAN ANAK GANDAI

TA
780
M534
2005

Bachelor of Engineering with Honours
(Civil Engineering)
2005

UNIVERSITI MALAYSIA SARAWAK

R13a

BORANG PENGESAHAN STATUS TESIS

Judul: ANALYSIS OF PILE GROUP

SESI PENGAJIAN: 2001 - 2005

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ANALYSIS OF PILE GROUP

MENSAN ANAK GANDAI

This project is submitted in partial fulfillment of
the requirements for the degree of Bachelor of Engineering with Honours
(Civil Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2005

Dedicated to my beloved family

ACKNOWLEDGMENT

I would like to express my sincere appreciation and gratitude to my supervisor, Dr. Vishwast Sawant for his continuous guidance and advice throughout this project work. His experience in the subject has drawn up to this project to an extent which cannot be expressed by mere words.

I would like to extend my thanks to all my lecturers for their support and suggestions. I would also like to express my sincere appreciation to my parents and to my brother and sisters for their support and encouragement.

I would like to acknowledge the help and encouragement of my friends that made the successful completion of this study possible.

ABSTRACT

In the present study, an analysis is presented for pile group embedded in homogenous soil mass. Pile and pile cap are modeled using beam element and plate element. The soil displacements are obtained using Mindlin's equation. The solution is obtained by imposing compatibility between displacements of pile an adjacent soil. A parametric study is carried out study the effect of pile spacing and a number of pile groups. Result indicated that the settlement of pile decreases with increase in pile spacing and number of pile in piles group. Effect of the pile cap thickness show that the settlement of the pile was increased with increase the cap thickness and it decreases with increase in the soil modulus. The result also shows that the settlement of pile increases with increasing the pile length.

ABSTRAK

Kajian ini dijalankan ke atas kumpulan cerucuk yang ditanam pada tanah yang sama sifat fizikal dan kimia. Dalam kajian ini cerucuk diwakilkan menggunakan alang manakala kepala cerucuk pula diwakilkan sebagai unsur yang leper dan rata. 'Displacement' pada tanah dikira menggunakan persaman Mindlin's. Penyelesaian dibuat mengambil kira perubahan pada cerucuk dengan tanah di sekelilingnya. Objektif kajian adalah untuk mengkaji kesan jarak antara cerucuk dan juga kesan bilangan cerucuk dalam kumpulan tersebut. Keputusan yang diperolehi menunjukkan 'settlement' pada cerucuk menurun dengan peningkatan jarak cerucuk dan juga jumlah cerucuk dalam kumpulan. 'settlement' pada cerucuk semakin meningkat dengan ketebalan kepala cerucuk (pile cap). Ianya juga dilihat menurun dengan penurunan pekali tanah serta meningkat dengan pertambahan pada kepanjangan cerucuk.

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CHAPTER 1

INTRODUCTION

Mankind has used pile foundation more than 2000 years. In the early days of civilizations, from the communication, defend or strategic point of view villages and towns were situated near to rivers and lakes. It was therefore important to strengthen the bearing ground with some form of piling. Timber piles were driven into the ground by hand or holes were dig and filled with sand and stones. Alexander the Great utilized in the City of Tyre in 332 BC, and the Roman used them extensively. Bridge builder during the Han Dynasty (200 BC – AD 200) also used pile. These early builders drove their piles into ground using weight hoisted and dropped by hand (Chellis, 1961).

Construction method improved more quickly during the Industrial Revolution. The industrial revolution brought about important changes to pile driving system through the invention of steam and diesel driven machines. More recently, the growing need for housing and construction has forced authorities and development agencies to exploit lands with poor soil characteristics. This has led to the development and improved piles and pile driving systems. Larger and more powerful equipment was built, thus improving pile driving capabilities. Pile materials also have become better. The early piles were always made of wood, and thus were limited in length and capacity. In 1890s, mankind started use steel and reinforced concrete, larger and stronger piles and install with advanced techniques of pile installation. Without these improved foundations, many of today's major structures not have been possible.

1.1 PILE FOUNDATIONS

Pile are long, slender, prefabricated structural members of timber, concrete and/or steel that driven into ground to form a foundation. Pile foundations are the part of a structure used to carry and transfer the load of the structure to the bearing ground located at some depth below ground surface, to the deeper soil or rock of high bearing capacity avoiding shallow soil of low bearing capacity. The main components of the foundation are the pile cap and the piles. The main types of materials used for piles are wood, steel and concrete. Piles made from these materials are driven, drilled or jacked into the ground and connected to pile caps. Depending upon type of soil, pile material and load transmitting characteristic piles are classified accordingly.

1.2 FUNCTION OF PILES

As with other types of foundations, the purpose of a pile foundation is to transmit a foundation load to a solid ground and to resist vertical, lateral and uplift load. A structure can be founded on piles if the soil immediately beneath its base does not have adequate bearing capacity. If the results of site investigation show that the shallow soil is unstable and weak or if the magnitude of the estimated settlement is not acceptable a pile foundation may be considered.

Further, a cost estimate may indicate that a pile foundation may be cheaper than any other compared ground improvement costs. In the cases of heavy constructions, it is likely that the bearing capacity of the shallow soil will not be satisfactory, and the construction should be built on pile foundations. Piles can also be used in normal ground conditions to resist horizontal loads. Piles are a convenient method of foundation for works over water, such as jetties or bridge piers. Pile foundations are used in the following conditions:

i. When the strata at or just below the ground surface is highly compressible and very weak to support the load transmitted by structure.
ii. When the plan of the structure is irregular relative to its outline and load distribution, which would cause non uniform settlement if a shallow foundation constructed. A pile foundation is required to reduce differential settlement.
iii. Pile foundations are required for the transmission of structural loads through deep water to a firm stratum.
iv. Pile foundations are used to resist horizontal forces in addition to support the vertical loads in earth-retaining, structures and tall structures that are subjected to horizontal forces due to wind and earthquake.
v. Piles are required when the soil conditions are such that a wash out, erosion or scour of soil may occur from underneath a shallow foundation.

vi. Piles are used for foundations of some structures; such as transmission towers, off-shores platforms, which are subjected to uplift.

vii. In case of expansive soils, such as black cotton soil, which swell or shrink as the water content changes, piles are used to transfer the load below the active zone.

viii. Collapsible soils, such as loess, have a breakdown of structure accompanied by a sudden decrease in void ratio when there is an increase in water content. Piles are used to transfer the load beyond the zone of possible moisture changes in such soils.

1.3 METHOD AVAILABLE

The various methods available for analyzing the load carrying capacity of pile are Load Transfer Method, Subgrade Reaction Approach, Randolph Method and Elastic Method. The load transfer method utilizes the relationship between the movements of pile at any point to shear stress at that point. The relevant soil data required in this method are curves relating the ratio of adhesion and the soil shear strength to the pile movement. In subgrade reaction approach the continuous nature of soil medium is ignored and the pile reaction at a point is simply related to the deflection at that point. In the Randolph method, the pile shaft and pile base are examined separately and then combined to the respond of the complete pile. The pile shaft is considered as surrounded by concentric cylinder of soil, with shear stresses on each cylinder the magnitude of which decrease inversely with the surface area of the cylinder. The solution of pile shaft is developed in term of shear modulus and Poisson ratio, as the mode of deformation around pile is primarily one of shear. The solution for pile base is obtained from standard solution given by Timoshenko and Goodier, by considering the base as a rigid punch and ignoring the pile shaft and surrounding soil. The elastic theory approach a pile is divided into number of uniformly loaded elements which are infinitesimally small elastic thin strip embedded in soil mass which is considered as homogeneous, isotropic elastic half-space. The solution is obtained by imposing compatibility between the displacement of pile and adjacent soil for each element of the pile. The displacements of pile are obtained by considering the compressibility between of pile under axial loading and soil displacements using Mindlins Equation.

CHAPTER 2

PILE CAPACITY

2.1 INTRODUCTION

The ultimate bearing capacity of pile is maximum load, which can carry without failure or excessive settlement of ground. The bearing capacity of a pile primarily depend on type of soil through which or on which it rests and on method installation. It also depends upon the cross section and length of the pile.

The following is the classification of the methods of determining the pile capacity:

i. Static analysis.

ii. Dynamic analysis.

iii. Load test on pile.

iv. Penetration test.

2.2 STATIC ANALYSIS

The ultimate bearing load of a pile is considered to be sum of the end-bearing resistance and the resistance due to skin friction.

$$Q_{up} = Q_{eb} + Q_{sf} \tag{2.1}$$

Where;

Q_{up} = ultimate bearing load of the pile

Q_{eb} = end-bearing resistance of the pile

Q_{sf} = skin friction resistance of the pile

However, at low values Q_{eb} of load will be zero, and the whole load will be carried by skin friction of soil around pile. Q_{eb} and Q_{sf} may be analyzed separately; both are based upon the state of stress around the pile and on the shear patterns that developed. Meyerhof (1959) and Vesic (1967) proposed certain failure surfaces for deep foundations. According to Vesic, only punching shear failure occurs in deep foundations irrespective of the density index of the soil, so long as the depth to width ratio is greater than 4 (this is invariably so for pile foundation).

$$Q_{eb} = q_b A_b \tag{2.2}$$

$$Q_{sf} = f_s A_s \tag{2.3}$$

Where,

q_b = bearing capacity in point-bearing for the pile.

f_s = unit skin friction for the pile-soil system

A_b = bearing area of the base of the pile

A_s = surface area of the pile in contact with the soil

The general form of the equation for q_b presented by various investigations is:

$$q_b = cN_c + 0.5\gamma bN_\gamma + qN_q \qquad (2.4)$$

This is the same form as the bearing capacity of shallow foundations.

2.2.1 PILES IN SAND

$$q_b = 0.5\gamma bN_\gamma + qN_q \quad \text{(For square or rectangular piles)} \qquad (2.5)$$

$$q_b = 0.3\gamma DN_\gamma + qN_q \quad \text{(For circular piles with diameter)} \qquad (2.6)$$

With driven piles, the first term involving the size of the pile is invariably negligible compared with the surcharge term qN_q. Thus, for all practical purposes;

$$q_b = qN_q$$

The surcharge pressure q is given by:

$$q = \gamma Z \quad \text{if } Z < Z_c$$

$$q = \gamma Z_c \quad \text{if } Z > Z_c$$

Where;

Z is being the embedded length of pile and Z_c the critical depth.

This indicates that the vertical stress at the tip of a long pile tends to reach a constant value and the depth beyond which the stress does not increase linearly with depth is called the critical depth. This is due to the mechanics of transfer of load from a driven pile to the surrounding soil. Large scale tests by Vesic (1967) in the U. S. A. and Kerisel (1967) in France indicate that the critical depth Z_c is a function of density index. For $I_p < 30\%$ $Z_c = 10D$; for $I_p > 70\%$ $Z_c = 30D$; and for intermediate values, it is nearly proportional to density index (D is the dimension of the pile cross-section).

2.2.2 PILES IN CLAY

$$q_b = cN_c + q \tag{2.7}$$

Since;

$N_q = 1$ and $N_\gamma = 0$ for $\phi = 0^0$