UNIVERSITI TEKNOLOGI MARA

# DESIGN FORMULATION FOR STATIC AND DYNAMIC RESPONSE OF PIPE PILES IN SAND

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# ABSTRACT

Open ended (OE) pipe piles are preferred in different engineering practice due to their handling, simplification and quality at low cost. However, there are ambiguities to the dynamic response of these piles. During construction, the soil enters the pile from the end until the in-filled soil generates sufficient resistance to prevent further soil penetration. Though this occurs frequently, the consequences of this phenomenon have received little attention; in particular, the behavior of plugged open-ended piles under combined static-seismic loading. Another phenomenon known as "Liquefaction" is one of the most common causes of structural failure during earthquakes. Liquefaction occurs as a result of increasing pore water pressure due to unexpected change in stress state under short-term loading, i.e., shaking during an earthquake. Therefore, hazards associated with soil liquefaction can cause structural damage and it is important to study the stability and safety of structures against soil liquefaction. Additionally, computational techniques have grown significantly in professional engineering analysis during the last few decades, and they have become a popular tool in foundation design that is widely acknowledged by the engineering profession. Therefore, advanced numerical models were adopted for solving practical geotechnical problems associated with deep foundations under static and dynamic excitations. The effect of scaling-up model, soil condition (dry and saturated), various slenderness ratios (L/D), and different acceleration histories on soil-pile response were also considered. From these investigations, design charts of CE and OE pipe piles were developed. The results of the based models were validated with the findings of the laboratory experiments. Two pile materials and conditions were adopted, Steel pile models, which were exposed to a vertical static load, while the Aluminum pile models were exposed to 50% of the allowable static vertical load and 50% of the allowable static lateral load. In order to provide the required strength to support the structural stability of the pipe pile, the pile designer in a seismically active zone will primarily need to obtain the maximum seismically induced displacement, liquefaction, bending moment (BM), and frictional resistance (FR) of the pile. Based on the findings from numerical simulations, correlation charts were proposed to assist the designers in estimating the seismic response of the pipe pile. It was observed that the increase of the excess pore water pressure is unaffected by the L/D. Yet, as a PGA increased; it was observed that the liquefaction-caused pile movement happened swiftly. The magnification of the ground acceleration resulted in boosting the pile BMs. Due to the liquified soil's decreased lateral support, the BM increases significantly in saturated soil compared to dry soil. In addition, a number of equations were developed to predict FR using regression analysis, where a high coefficient of correlation values is obtained (ranging between 0.94 and 0.98). Noting that despite of the effects of slenderness ratio, acceleration history, and soil condition, it was observed that the FR increases in a dense sand layer compared to a loose sand layer. The proposed predictive tools could assist designers in preliminary checks of the frictional capacity of pipe piles in seismic active areas. A three-dimensional finite element modelling has been developed using MIDAS GTS NX software. The pile is modelled as a linear elastic, the surrounded dry soil layers were simulated adopting a modified Mohr Coulomb model, and the saturated soil layers were simulated using modified UBCSAND model. In light of this, the evaluation of the current study can be used as a guide for the preliminary analyses and designs for engineering practice.

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To My Little Princess

ELMA

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# CHAPTER ONE
# INTRODUCTION

## 1.1 Research Background

Deep foundation is essential when the soil less than 3 - 5 m could not resist the structural load acting on a shallow foundation. This is because the bearing capacity is inadequate and the settlement of the foundation is more than the stipulated limits from the code of practice. For the design of a deep foundation, piles are presumed to transfer the axial and lateral loads into the ground, and decrease the settlement. However, the effects of the combined loads are generally ignored in engineering practice since there are uncertainties to the precise definition of soil-pile interactions. Piles are usually and advantageously employed to transfer vertical forces, which are mostly generated by the superstructure. However, there are cases where the piles are constructed to resist lateral loads. In many situations, in addition to vertical loads, piles transfer lateral forces caused by strong winds, earthquakes, slopes failure, and liquefaction-induced lateral spread. As a result, a pile can be subjected to the combined action of vertical and horizontal loads depending on the nature of the construction.

Figure 1.1 shows the mechanism of load distribution along the pile shaft with different stages. During applying of $V_u$, the vertical load at a specific distance approach to zero and at the pile head the total axial load is $V_u$. That may be attributed to the load $V_1$ set to be less than the structural pile capacity, hence the pile mobilizes skin friction because the pile is long. Therefore, the applied load ($V_1$) is diminished by the pile skin resistance and it was not enough to reach the pile tip. However, when the loads are increased, the geotechnical capacity increases to withstand the load increase to the pile without exceeding the structural capacity. Hence this will mobilise the skin friction and bearing capacity of the pile. Yet, with increasing applied load, the pile skin friction may reach to level of failure (ultimate value). In such case, the additional applied load will be carried by the pile tip until the soil below the pile tip experiences punching failure. In reality, soil shear strength and its elasticity are both controlled by the mobilization of the skin and tip resistance during loading. Anbazhagan et al. (2013) stated that the pile