CHAPTER I.

INTRODUCTION

Introduction.

In most of pile foundations, the number of piles are determined by the simple procedure of dividing the total load by the allowable load per pile. Though many pile foundations designed in this manner were satisfactory, but now and then excessive and unexpected settlements occured. These incidents indicated that the settlement of an entire pile foundation was not necessarily related to the settlement of a single pile, even at the same load per pile. They led to an obvious conclusion that the knowledge of the settlement prediction of a pile group constitues an important part of the information necessary for the design of a satisfactory pile foundation.

With the advance of computers, more sophisticated methods of analysis have been developed to predict the settlement of pile foundation. The most popular one is the finite element method. This method has been widely used to analyse single pile behavior with the idealization of the pile and soil as two dimensional plane strain model (1) or axially symmetric model (2). However, both idealization cannot predict the pile-group settlement precisely because most of pile groups are not axially symmetric, particular for those with irregular shape. Thus, the three-dimensional idealization is

necessary for such analysis.

Objectives and Scope of Research.

The objectives of this study are as follows:

1. to modify the linear three dimensional isoparametric finite element program, THREED, developed by Dr. Karoon Chandrangsu of Chulalongkorn University, to include the effect of geometric nonlinearity.

2. to present a method of settlement prediction of pile foundation by the computer program in 1.

3. to investigate and compare the results of the proposed method with an existing method presented by Poulos and Davis (3,4).

The scope of this research is to formulate a method of predicting the settlement of axially loaded pile groups. Focus is put on a case of the pile groups situated in a soft soil stratum with the pile tips embedded in an underlying stiffer soil stratum and different soil layers underling the pile tips are also included in the analysis. Applications of this method to the settlement problems of pile groups in Bangkok area are presented and only the driven pile groups in which the pile tips do not pass through the first sand layer are considered.

Assumptions.

The principle assumptions applied in this research are :

1. The soil and the pile are assumed to be isotropic elastic materials with Young's moduli and Poisson's ratios E_s,

ν_s and E_p, ν_p respectively.

2. The pile soil interface remains elastic and no slip occurs.

3. The pile cap is perfectly flexible and all piles are equally loaded.

Literature Review.

Terzaghi and Peck (5) presented the method for predicting the settlement of shallow foundations on clay. The method was based on Terzaghi's theory of consolidation assuming that the total settlement results from a one dimensional strain of the clay layer and the initial excess pore pressure is equal to the vertical stress increment. For pile foundations, they found that above the level of the lower third-point of the pile length, the water content of the clay remains unchanged, and below this level consolidation preceeds as if the building was supported on an equivalent mat loaded at that level. To compute the distribution of the load from the mat they used the approximate method by assuming that the load spreads from the mat at an angle of one in two from the vertical.

Tomlinson (6) suggested that the total settlement of the shallow foundation equals the sum of the immediate and consolidation settlement. The immediate settlement can be calculated by using elastic theory while the consolidation settlement can be predicted based on Terzaghi's theory of consolidation with some modification. For pile foundations, Tomlinson presented the assumption that the pile group behaves as a block foundation with a degree of flexibility

and it can be replaced by the equivalent mat which is bigger than the original size of pile group by assuming that the load spreads from the original pile group at an angle of one in four from the vertical. The level of the equivalent mat depends on the soil condition which can be classified into three cases. First, piles in clay, the base of the equivalent mat is assumed to be at a depth of two-thirds of the length of the piles. Second, piles situated in clay with pile tip embedded into an underlying sand stratum, the base is assumed to be at a depth of two-thirds of the length of the piles embedded into sand layer. Third, piles with pile tip on the rock, the base is assumed to be at the level of rock and the area of the equivalent mat is the same as the original one.

Meyerhof (7) suggested that generally, the settlement of pile foundation under the safe design load can be roughly estimated as an equivalent pier. He also presented an empirical expressions to estimate the total settlement of pile foundations in cohesionless soil using the results of static and standard penetration tests.

Poulos and Davis (3,4) presented the method for predicting the settlement of pile foundations based on the theory of elasticity, which employed Mindlin's equations for subsurface loading within a semi-infinite mass. They analysed the settlement of a single pile and studied the interaction of two piles. The settlement of pile groups can be analysed by a relatively simple extension of the single pile analysis by using the principle of superposition. They also carried out parametric analyses for the effects of pile and soil characteristics and prepared series of solutions which can be applied

to many practical problems.

Desai, Johnson and Hargett (8) presented finite element analyses of piled foundation system in which the foundation, the piles, and the soil were represented by finite elements, without performing a full three-dimensional analysis. The system was simulated by an equivalent plane strain idealization in which a row of piles in the group was represented by a strip of unit width and length with equivalent axial stiffness properties. Even with the foregoing idealization to a two-dimensional system, the predicted behavior in terms of progressive settlements and distributions of loads in the pile showed satisfactory correlation with corresponding observations.

Pressley and Poulos (9) studied the nonlinear load settlement behavior of square-configuration pile groups. The groups were represented by an equivalent axially symmetric model and a nonlinear finite element was used to examine the mechanisms of group behavior and their variation with pile spacing. It was shown that, at close spacings, the block failure machanism occurred. As the pile spacing increased, the failure mechanism gradually changed to the single pile mode. The values of group settlement ratio and group efficiency were in reasonable agreeement with the values derived from the method of Poulos and Davis (3,4).