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Maupah, Denford S

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Settlement Analysis of Deep Foundations

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Student Name: DENFORD S MAUPAH
Student No: 2063874

Supervisor: DR THUSHAN C EKNELIGODA

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ABSTRACT

This paper reviews the various methods of settlement prediction of single piles and pile groups founded in cohesive, cohesionless and layered soils. The methods of settlement analysis can be grouped into three classes which are: (i) purely empirical such as that by Mayerhof (1959) for both single and pile groups, Focht (1967) for single pile and Skempton (1953) applicable to pile groups, (ii) simplified analytical or theoretical, which use elastic theory to come up with design charts and (iii) numerical methods which are computer based solutions. These range from the complex finite element and boundary element methods to fairly straightforward 'Pile' computer programme found in Prokon.

The settlement of single piles is dependent on the applied load, pile length, pile diameter and the type of soil along the pile shaft and at the base of the pile. The load-carrying capacity of a pile is influenced by the same factors which affect settlement, except the applied load which does not influence the pile capacity in any way. Single piles can be straight-shafted, sometimes referred to as conventional piles in this report, or have an enlarged base. Pile base enlargement has the effect of increasing the pile base, and hence, total pile load capacity, while at the same time leads to a reduction in settlement of a pile. Piles in sand tend to settle less but develop more shaft resistance than those founded in clay, for a pile of same geometry and supporting same load. However, piles founded in cohesive soil mobilise higher tip resistance than those founded in sand for the same applied load.

The settlement of piles predicted using various empirical, theoretical and/or analytical methods has displayed a fair measure of agreement with the computer program-determined settlement. Very close matching has also been exhibited with results of manual calculations, computer analysis results and those settlements measured from test piles in case histories. In some few cases, the level of agreement was not very close and this can be attributed mainly to the soil modelling in order to derive input soil parameters compatible with 'Pile' computer method that has been adopted for computer analysis.

The analysis of a single pile is extended to the consideration of the settlement interaction between two identical piles, a system which represents the simplest form of a pile group. Such an analysis is then extended to the case of a general floating pile group. Due to the large number of variables involved, it is not possible to present parametric solutions for all the possible situations. Consequently, in this paper, the settlement analysis of 2x1, 2x2, 3x3 and 4x4 pile groups have been considered. Pile group settlement is dictated by pile length, pile spacing, pile diameter, founding soil type pile group size and the applied load.

The load-carrying capacity of a pile group can be notably less than the sum of capacities of the single piles making up the group. In any situation, both the immediate and consolidation settlements of the group are greater than those of a single carrying the same working load as that supported by each pile in the group. This is so because the zone of soil which is stressed by the entire group extends to a much greater width and depth than the zone beneath a single pile. Therefore, the group action failure mode needs to be checked during the design of pile group foundation and similarly, the single pile failure mode should also be evaluated especially where an individual pile in the group leads to the whole pile group failure. Therefore explicit settlement checks must be made an integral part of any pile foundation design.