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ORIGINAL ARTICLE

Behavior of pile group incorporating dissimilar pile embedded into sand

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Dissimilar pile;
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Abstract Piles are recommended to transfer the superstructure loads safely through soil by friction resistance and end bearing into firm bearing stratum. Piles drive their load via weak soil into competent bearing stratum. Piles in group are designed of similar length, diameter and working load. Except in special cases such as raft on piles which may be attentionally of different lengths. Dissimilarity in piles within a group may result from uncertainties in soil conditions, or imperfection in pile construction. Soil conditions may force the designer to design pile groups in a building having different lengths. Studying the behavior of pile groups incorporating dissimilar piles, in literature is scarce. The paper is devoted to study, through small scale models in laboratory, the behavior of pile groups incorporating one dissimilar pile. The aim of the research work was to emphasize the effect of dissimilar pile on the behavior of pile group through load settlement relationship. The study revealed that the end bearing of the group due to the existence of dissimilar pile, decreases as the number of piles in the group increased. The deficiency of two-pile group containing one dissimilar pile attains 90%, while in a group containing 9-piles it reaches 5%.
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1. Introduction

Dissimilarity in Piles may result due to uncertainties in soil condition or imperfection in pile construction. As an example of the former case the sequence of pile driving produce different soil conditions within the soil zone enclosing the pile group, consequently piles of different length may be constructed. This phenomenon is obvious in case of piles driven in sandy soil, the later case was discussed by [6] and [1,3].

Dissimilarity between piles in a group may happen in case of inclined competent stratum on which pile group are seated. Dissimilarity in pile may be attentionally designed such as raft on piles [5]. Rehabilitation of pile foundations using piles of different diameters, material and lengthes may result dissimilar piles in a group [2]. Pile within a pile group is considered dissimilar, if the pile has different length, different diameter and different material. The problem has not attracted the attention of researchers, may be due to that the problem arises during construction, and usually practicians have no time to report and interpret a case study for publication. Consequently the problem is worth investigated [4] and implemented a hybrid approach to analyze pile groups containing dissimilar piles. Piles of different length, different diameter are considered dissimilar in the analysis [7] analyzed the interaction between two-pile group, one pile dissimilar to the another.

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2. Testing equipment

To study the behavior of pile groups, incorporating one dissimilar pile, buried in sand, laboratory tests were conducted on small scale models of aluminum piles. Pile groups containing 2,3,6 and 9 piles were considered. The pile groups are attached to pile cap free standing from soil. The pile caps are machined from aluminum plates. The caps have smooth faces and a notch at the center of the top face for mounting a calibrated proving ring of 2kN maximum capacity and 0.01kN accuracy via ball bearing. Two-dial gauges – of accuracy 0.01 mm – were used to measure the vertical displacements and rotations of the pile group, the dial gauges were attached vertically far apart on the top surface of the pile cap. A total of Nine circular aluminum piles of diameter 12 mm, and 400 mm in length are machined from aluminum rods. For dissimilarity reasons steel, plastic, and timber circular piles of diameter 12 mm and lengths 400, 350, 300, and 200 mm were prepared and used. Aluminum piles of diameter 12 mm and length 350,300 and 200 mm were also prepared. Similar piles of the same material were used but of diameters 8 mm and 6 mm for the same reason. This means that 33 piles are manufactured. Combination of these piles was used to form pile groups with dissimilar piles. The general layout of the equipment used in performing the loading tests is illustrated in Fig. 1. The vertical displacements of the pile group and the rotation of the pile group were obtained from dial gauge readings. The load was applied vertically and concentric on the pile cap model using controlled manually operated loading machine. The soil bin is made out of two steel rings each of 300 mm height and 750 mm diameter. These rings were assembled to form a soil bin of total height 600 mm. The sides of the soil bin were strengthened using circular steel plates at top and bottom of each ring to prevent any lateral deformation of the side walls and to facilitate the erections of the steel rings using steel bolts. The vertical steel ribs are added to each ring and welded to the boundary circular plates of each ring. The soil bin is placed on two rigid steel girders resting on the ground, accurately vertical. Spirit level was used to ensure vertical and horizontal levels of test setup. Reaction frame supporting a loading machine is attached to the soil bin. The dimensions of the soil bin are big enough to overcome the effects of the boundary conditions on the piles response. Table 1 shows the testing program for loading two pile groups, (G1). The arrangement of the piles in the groups was kept one pile in the groups unchanged to be aluminum pile of diameter 12 mm, and length 400 mm the reference pile, and modulus of elasticity, E_p of 70 GPa, that's to say E_p/E_s equals to 1400. The other pile was changed in each experiment creating dissimilarity in the pile group as shown in Table 1. The dissimilarity occurs in pile material, as it is changed to be steel, $E = 200$ GPa, timber, $E = 15$ GPa, and plastic, $E = 3$ GPa, also in piles length to be 350 mm, 300 mm and 200 mm, finally dissimilarity occurs in pile diameter to be 8 mm, and 6 mm as shown in Table 1.

The second group G2 was accomplished on 3-pile groups placed in triangle configuration the properties of dissimilar pile were changed according with Table 2. One dissimilar pile was incorporated in each experiment as the sequence of group G1, and the other two piles were kept unchanged and having the

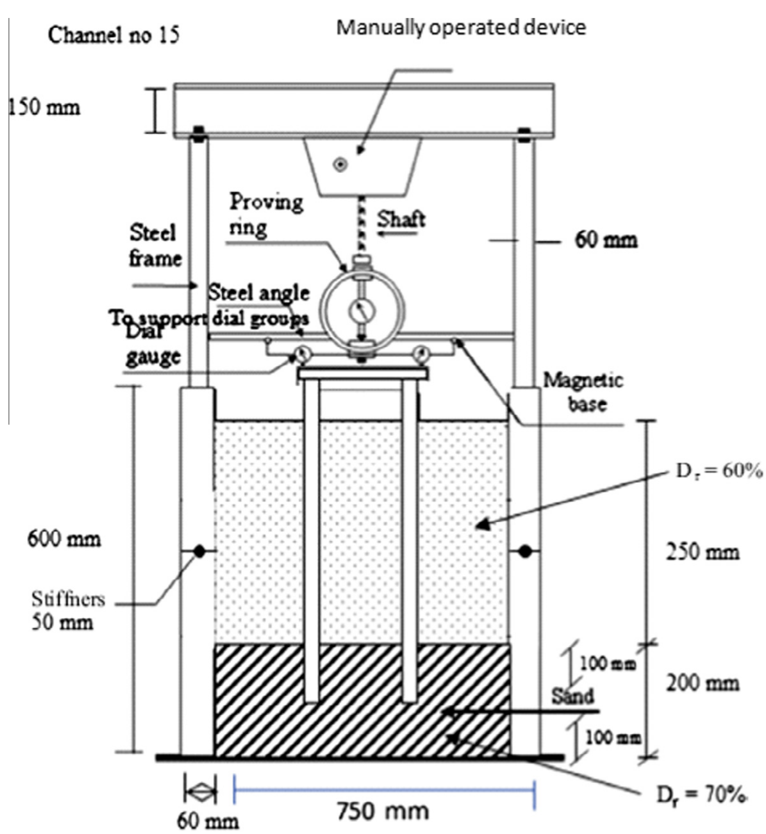

Figure 1 Complete set-up of testing procedures.

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