EFFECT OF PILE CONFIGURATION ON LATERAL LOAD ANALYSIS OF PILE GROUPS IN SAND

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ABSTRACT: An experimental investigation is conducted on model pile groups under static lateral load to determine pile-soil-pile interaction and the effect of pile configuration of pile groups in sand. Tests are conducted for two different configurations of pile group. A square group and a circular group with 9-piles in each group were arranged and tested for lateral load. Three different spacing were adopted in each group and repeated for three different densities of sand. Graphs are plotted for comparative study and conclusions are drawn.

1. INTRODUCTION

Pile foundations are frequently used for the structures that are to be constructed on weak soils. In addition to vertical forces, they are also subjected to horizontal forces, if the site lies in earthquake prone areas or if piles are used at harbour. Piles are commonly used in groups. Different configurations of pile groups such as rectangular, square, circular, hexagonal etc. are adopted based on the number of piles in a group. The arrangement of piles is to be made in such a way that it is symmetrical about the point of load application. A pile group under lateral load has pile-soil-pile interaction effects. Poulos (1971) has done pioneer work on lateral load behaviour of pile groups and developed interaction factors. Shibata et al. (1989) conducted laboratory tests of model pile groups under lateral loading and concluded that pile-soil-pile interaction effects were significant upto 5 times the pile diameter. Mc. Vay et al. (1995 & 1998) conducted centrifuge tests results in sand and reported that the values of $p$-multipliers are found to be independent of soil densities and only functions of pile group geometry. In order to understand the effect of pile configuration under lateral load the present study is proposed. In the present study two patterns of pile groups were tested namely square group and circular group of 9-piles.

2. EXPERIMENTAL STUDY

Laboratory tests were conducted for model pile groups of two different configuration namely square group and circular group of nine piles each. Pile length, pile diameter and pile material is constant for all tests.

2.1 Test Material

2.1.1 Soil

Sand was used in conducting experiments in loose, medium and dense state. The specific gravity of soil is 2.67. The uniformity coefficient is 4.6 and the coefficient of curvature is 1.18. The soil is designated as ‘poorly graded sand’ SP as per IS classification 1498-1970.

2.1.2 Piles

Model piles made of aluminium with 8mm external diameter and 0.9 mm thick were used in testing. Length of pile is 560 mm. The piles were treated as long piles (L/R > 4, IS:291-1979).

2.1.3 Pile Cap

A steel pile cap 2.5 mm thick was used to connect piles. The pile head is connected to pile cap by means of bolts.

2.1.4 Test Tank

A model test tank with dimensions $600 \times 600 \times 700$ mm was used in the laboratory tests. It consists of steel frame fabricated from angles with plexi-glass sheets fitted to the angles along the lateral faces. The bottom of the tank is made of steel sheet. For the size of the piles, the test tank is sufficiently large to minimize the size effects. The tank provides a minimum lateral clearance of 11d and a clearance of 10d below the piles to satisfy the minimum requirements to avoid friction between the soil and the container (Meyerhof 1959 & Kishida 1963).

2.2. Experimental Set up

Piles are connected to the pile cap and are placed in to the tank. The test tank is then filled with sand. A pulley is fixed at the top edge of the tank to facilitate the application of lateral load. A cable connected to the pile cap which passes over the pulley and the loads are suspended through the cable. The dial gauge is placed in contact with the pile cap to record the deflections. The least count of the pile group is 0.01 mm with a range of 25 mm.
2.3 Tests Conducted

Lateral load tests were conducted for a 3 × 3 pile group and a 9-pile circular group in sand for three different states, loose (15.6 kN/m³), medium (16.5 kN/m³) and dense (17.1 kN/m³). The tests were repeated for three different spacing 2d, 4d and 6d. Lateral load is applied to the pile cap by means of a cable connecting pile cap, which passes over the pulley connected to the sand box. Loads were applied in increments of 20N and pile cap deflections were recorded.

3. RESULTS AND DISCUSSION

3.1 Comparison of Experimental Results for Different Densities of Sand

Comparison of experimental values for different densities of sand for a 9-pile square group and circular group are presented from Figures 1 to 9. In the comparative study for a density of 15.6 kN/m³ corresponding to s/d = 2, it is observed that the experimental values of square and circular groups are close to each other. Deflections of a circular group are slightly larger than that of a square group. Also, when s/d = 4, similar behaviour is seen. Most of the results of square and circular groups were found to be overlapping. This effect is seen for all densities of sand.

Fig. 1: Comparison of Deflections for Square & Circular Groups (Loose Sand)

Fig. 2: Comparison of Deflections for Square & Circular Groups (Loose Sand)

Fig. 3: Comparison of Deflections for Square & Circular Groups (Loose Sand)

Fig. 4: Comparison of Deflections for Square & Circular Groups (Medium Sand)

Fig. 5: Comparison of Deflections for Square & Circular Groups (Medium Sand)

Fig. 6: Comparison of Deflections for Square & Circular Groups (Medium Sand)
4. CONCLUSIONS

1. In the above analysis it is observed that deflection of circular group are close to a square group for different densities of sand.

2. There is little effect of spacing at s/d = 2 and s/d = 4, where as at s/d = 6 the deflections are slightly higher for a circular groups than square groups.

3. Finally, it can be concluded that the effect of pile configuration is insignificant in pile groups subjected to lateral load due to which the horizontal interaction factors are independent of pile configuration for the n-pile group.

5 REFERENCES


