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An Experimental Study on Laterally Loaded Piles in Sand

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Abstract**—*****The behaviour of pile under lateral load is studied through laboratory experiments on model cemented group of piles driven into testing tank containing dry river sand. The load-displacement diagrams were drawn to study the effect of strength comparison between the group of cemented piles and different densities of sand on the lateral load capacity of pile. It was found that the lateral load capacity of piles increases with increase in number of piles and increase in sand density. It is also found that lateral load capacity is more in high density sand as compared to that of low density sand.***

Keywords: ultimate lateral load capacity, cemented pile, sand.

I. INTRODUCTION

Pile foundations are commonly used to resist axial and lateral loads applied to structures. Piles are often subjected to lateral loads particularly in quay and harbour structures, pile supported earth-retaining structures, in transmission tower foundations etc. For proper functioning of such structures, two criteria must be satisfied: (1) a pile should be safe against ultimate failure; and (2) normal deflection at working loads should be within the permissible limit. For design of such piles, ultimate lateral resistance of a pile is also required. The Behavior of piles subjected to lateral loads is governed by the interaction between the pile and the soil. Pile properties, including pile stiffness and geometry; soil stress–strain behaviour, including shear strength, stiffness, density and the pile/soil interface play important roles in the response of piles subjected to lateral loads. Lateral loads on piles are developed both by the superstructure and by the wave propagation through the soil. The dynamic loads due to the horizontal movement of the superstructures are mainly generated by wind effects, machine vibrations, impact of vehicles or boats; the loads due to the wave propagation are primarily because of earthquakes. Therefore, the total forces are the result of two types of interaction: an inertial one from the movement of the superstructure and a kinematical one from the soil motion.

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II. MATERIAL

A. Soil

The soil used in the present study is collected from Bhadra river sand, Galagnath, Haveri. The grain size analysis test was carried out according to IS 2720 (Part 4)-1985. The basic and index properties of the sand are also determined in the laboratory according to IS Code of practices and the results are summarized in Table.1 the soil is graded as well graded soil and symbolic representation as *SW*.

Table.1 Basic index properties of Bhadra river sand

Parameters	Results
Specific Gravity (G)	2.45
Uniformity coefficient	2.9
Coefficient of curvature	1.01
Maximum dry unit weight ($\gamma_{d\,max}$) (kN/m^3)	15.7
Minimum dry unit weight ($\gamma_{d\,min}$) (kN/m^3)	14.81
Angle of internal friction$(\Phi)_{min}$	25°
$(\Phi)_{max}$	36°

B. Testing tank

The testing tank of size 1000mm x 1000mm x 1000mm was prepared using good quality wood of sufficient thickness. The dimensions of the tank are fixed taking care to avoid the boundary effects. The sides of the testing tank were strengthened in the horizontal direction using wooden planks of 40mm width and 20mm thickness to avoid the bulging of the tank during preparation of sand bed and also at the time of loading the pile.

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C. Loading frame

The loading frame consists of pulley arrangement supported over bolted steel connection with the tank as shown in fig. below. The arrangement is made to apply the load laterally.

D. Dial gauge

The two dial gauges are fixed to the steel bar which is placed in the sand and allowed to touch the pile cap. The average of two Dial gauges readings should be taken.

E. Casting of piles

The model pile is casted in the laboratory the casting of the pile is carried out by preparing the mould of required dimensions. Cycle steel bar of 1 mm is used as the reinforcement and cement slurry is poured in the prepared mould. After removing the pile from casting, curing is done for 28 days.

III. EXPERIMENTAL SETUP

The present investigation was carried out in the geotechnical engineering laboratory of the civil engineering department S.K.S.V.M. Agadi College, Laxmeshwar, Karnataka, India. All the tests were conducted using the setup shown in fig 2, which consists of sand tank, testing piles, loading frame, dial gauges and proving ring. The dial gauges, 5 tons with least count of (1div = 0.063KN) proving ring are of 25mm run with 0.001mm least count respectively. The following figure shows photo graphic view of experimental setup.

A. Preparation of Sand Bed

The procedure of sand pouring technique is explained below. The 5cm thread and bolt was fixed to the end of the funnel at downward direction and the sand is filled with the help of bucket in to the funnel, the tip of the bolt should touch at surface of bottom layer as goes on filling the sand the funnel should be rise up slowly to the touching the tip of bolt in to the surface of achieved sand layer, and required density is achieved after that the single pile should be placed at center of the box, and the sand pouring technique is continues till the full of wooden box, the surface of sand layer is leveled with the help of glass piece. The test was conducted in different types of densities such as low densities, high densities with cemented pile.

Fig.1: Shows the photo graphic view of experimental setup.

B. Loading procedure

The schematic diagram of the test setup, loading arrangement, and model pile group with pile cap is shown in Fig. 1. Sand was placed in the test tank in layers and was compacted well to attain the required density. The model pile was then installed into the centre of tank filled with sand by driving it vertically. The tests were then conducted. The lateral load was applied to the pile top or pile cap through a pulley arrangement with flexible wire attached to the pile top or pile cap. The same end was attached to the loading pan. The loads were applied by dead weight (slotted weights) over the loading pan. Mechanical magnetic base dial gauges having a sensitivity of 0.01 mm were used for measuring lateral displacements. Load increment was continued until the pile exceeds permissible limit of lateral movement or until the dial gauge shows maximum deflection. Load-displacement graphs were plotted. From this graph the ultimate lateral load is calculated. The photograph of the experimental setup is shown in Fig.1.

IV. RESULTS AND DISCUSSION

The load-displacement curve is plotted from the test results, the ultimate load is obtained by the tangent intersection method, in which initial and final tangent lines are drawn to the load-displacement curve and the point of intersection of these tangent line is the ultimate load (Qu).The load-displacement curves of cemented pile for the high density of 15.7kN/m^3 and low density of 14.81kN/m^3 are shown in figures 4.1,4.2,4.3 4.4 and 4.5,4.6,4.7,4.8 respectively, the ultimate load (Q_u) obtained from tangent intersection method for the cemented pile for the density of 15.7kN/m^3 is 0.043kN and for 14.81kN/m^3, the ultimate load (Q_u) is 0.022kN. From which it is clear that load carrying capacity of the pile depends on the group of piles and density of sand.

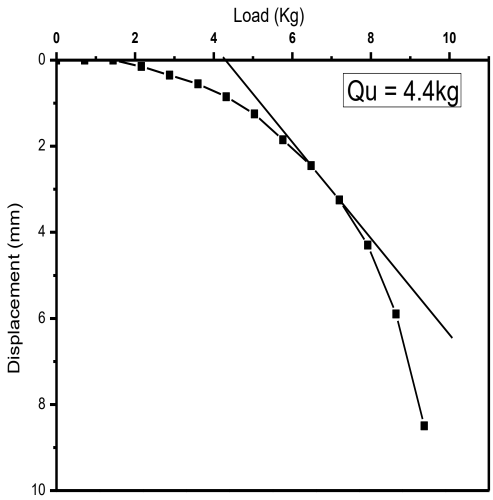

Fig.4.1: Shows cemented single pile embedded in high density of sand.

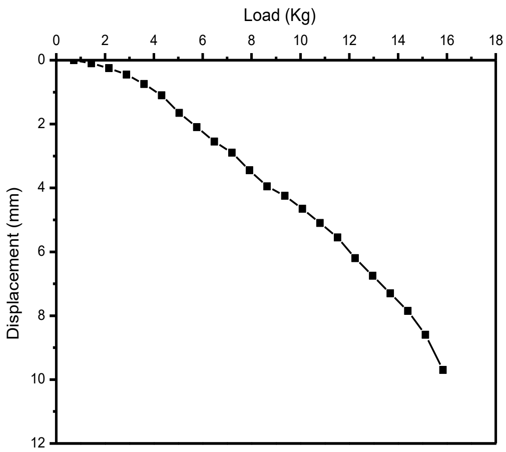

Fig.4.2: Shows cemented two piles embedded in high density of sand.

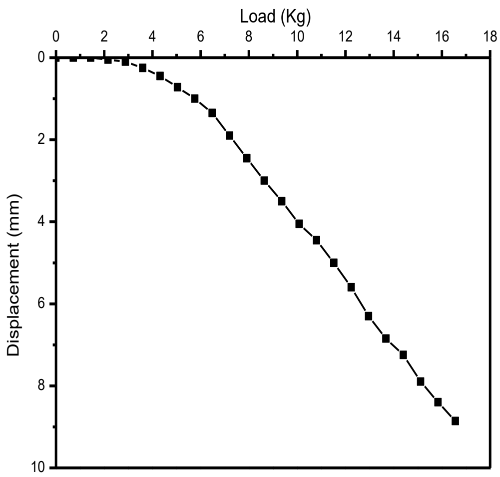

Fig.4.3: Shows cemented three piles embedded in high density of sand.

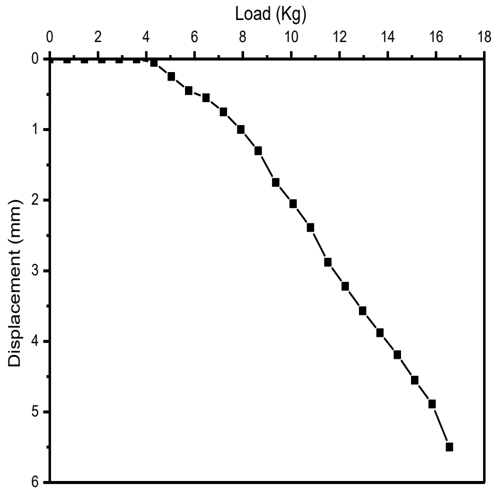

Fig.4.4: Shows cemented four piles embedded in high density of sand.

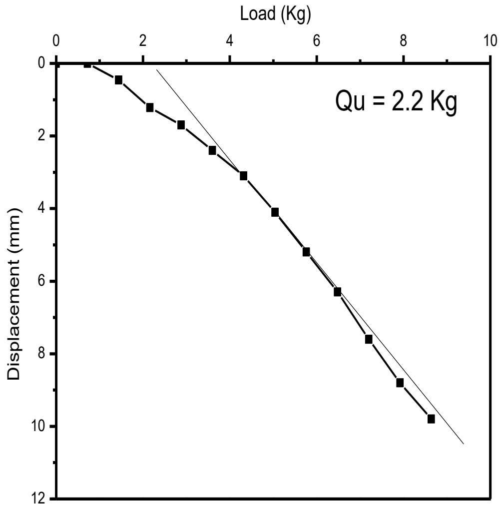

Fig.4.5: Shows cemented single pile embedded in low density of sand.

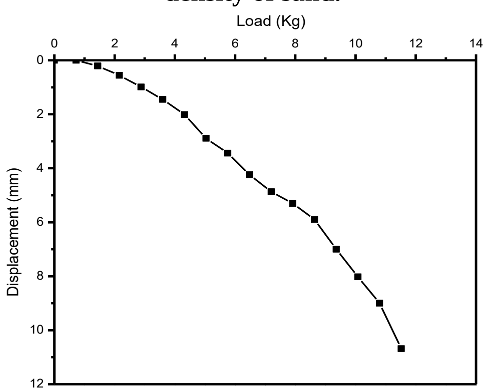

Fig.4.6: Shows cemented two piles embedded in low density of sand.

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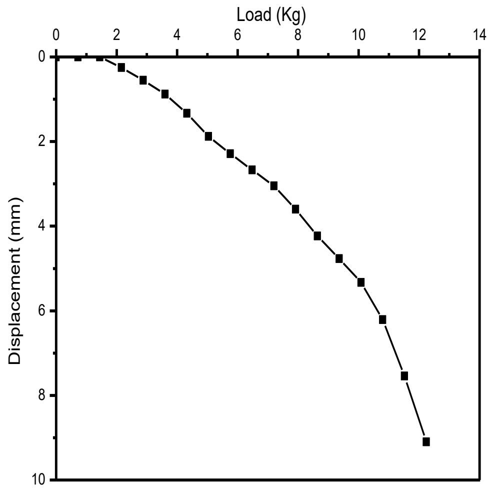

Fig.4.7: Shows cemented three piles embedded in low density of sand

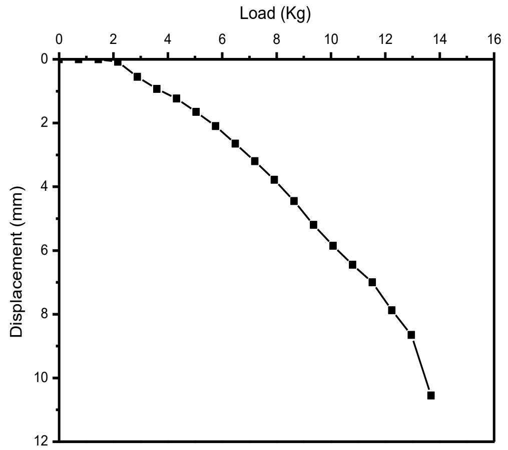

Fig.4.8: Shows cemented four piles embedded in low density of sand.

V.CONCLUSIONS

Laboratory model test results for pile materials and density of sand have been presented. Based on the results, following conclusions were drawn.

- The increase in the density of sand leads to the increase in load carrying capacity.
- The rate of displacement is lesser at the initial loads and increases with the increase in the loading.
- As the angle of wall friction increases, the ultimate bearing capacity of piles also increases.
- The ultimate load carrying capacity of the pile is high in case of high density sand as compared to low density sand.
- The lateral load capacity of pile and pile group increases with increase in density of the sand for same length and diameter.

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