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STUDY OF SINGLE PILE IN SLOPE SUBJECTED TO INCLINED LOAD

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Abstract: Deep foundations, including driven piles, are used to support vertical loads of structures and lateral forces. Typical structures subjected to lateral loads include bridge abutments, transmission tower, Sand off shore platforms. Traffic, wind, wave, and seismic forces are common types of lateral loads subjected to pile foundations. These structures may be subjected to large lateral loads, such as violent winds and earthquakes. Widely used types of foundations for these structures are pier foundations, subjected to lateral loads is similar to that of a short rigid pile, because both elements seem to fail by rotation developing passive resistance on opposite faces above and below the rotation point. This paper describes the results of several experimental studies performed on laterally loaded and load inclined on short pile located near slopes. Initially, in this paper, the results of tests of single pile subjected to lateral loading, in homogeneous sand with 30° slopes and load with inclination of 15° and 30° were carried out.

Keywords: Lateral loading capacity, Lateral deflection, Pile, Slope

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INTRODUCTION

Deep foundations, including driven piles, are used to support vertical loads of structures and lateral forces. Typical structures subjected to lateral loads include bridge abutments, transmission tower, sand offshore platforms. Traffic, wind, wave, and seismic forces are common types of lateral loads subjected to pile foundations. These lateral forces are sometimes much greater than the weight of the structure itself. Therefore, the foundation systems must be designed to resist both axial forces and lateral forces.

Generally, vertical piles resist lateral loads or moments by deflecting laterally until the necessary reaction in the surrounding soil is mobilized. The magnitude of resisting force increases as the lateral deflection increases until it reaches an ultimate value.

2. LITERATURE REVIEW

Sr No.	References	Evaluation Approach
1	Gabr, M. A., Bordan, R. H.,(1990)	They examined lateral capacities of piers constructed in and near sloping ground and estimated the ultimate soil resistance, pu.
2	Chen and Martin (2001)	It shows the effects of an embankment slope on lateral pile response in c-φ soil by conducting finite difference analyses.
3	Reese *et al* (2006)	They determined the ultimate lateral resistance of a single pile located on a slope loaded in the downslope direction.
4	Mirzoyan (2007)	He conducted full-scale lateral load tests in a cohesionless soil.
5	Muthukkumaran *et al* (2008)	They conducted centrifuge model tests to examine the effects of slope on p-y curves in dry sand

3. MATERIALS & PROPERTIES

The materials used for the dissertation work was Kanan sand and pile of various lengths made up of mild steel. The pile of mild steel having different sizes were fabricated.

3.1 Test Sand

For the model tests, cohesionless, dry, clean and wash Kanan sand was used as the foundation material.

3.2 Model Pile

The model pile of size L/D=10 was fabricated by using mild steel material. The model pile was length of 10cm and 1 cm in diameter.

3.3 Experimental Set Up

The test tank size of 0.7m x0.4mx 0.5m deep was chosen to avoid any tank-wall effect on the lateral capacity of the piles. The lateral load was applied though a pulley arrangement. The pulley arrangements was fabricated such that the lateral loads could be applied in forward (toward sloping ground). The tests were conducted on sloping ground, (1V:2H) with same (Dr) relative density. A single pile was tested on each model configuration at the crest of the slope, b=2.5D, 5D, 7.5D in the embankment, away from the slope. For all tests, the pile head was maintained as a free-headed condition.

3.4 Laboratory Tests

The various laboratory tests were performed to decide the different geotechnical and engineering properties of sand. The properties of sand used are as shown in Table 1.

Table1: Properties of Sand Used

Sr. No.	Properties	Values
1	Type of soil	Sandy soil
2	Specific gravity	2.57
2	γ_{max}	17.67 kN/m^3
3	γ_{min}	16.94 kN/m^3
4	Angle of internal friction ϕ	27.5º
5	Average grain size (D60)	1.10
6	Effective grain size (D10)	0.45
7	Coefficient of uniformity (Cu)	2.44
8	Coefficient of curvature (Cc)	1.03
9	I. S. Classification	Medium sand, SP grade

3.5 Laboratory Lateral Load Test

For the experimental investigations, the lateral load tests was conducted on sand and to evaluate the lateral load carrying capacity and lateral deflection. In the laboratory it was maintained by refilling the tank after each test by sand raining technique by funnel method to same density.

3.6 Laboratory Set-Up

Laboratory set-up consisted of a tank, a horizontal and inclined loading frame, a model footing, pulleys and dial gauges. The apparatus required for this test are horizontal, inclined loading equipments and an instrument to measure the applied load and resulting lateral deflection. Laboratory set up is shown in Fig.1

Figure 1: Laboratory set up

3.7 Test Tank

The test tank was made of 4 mm thick having internal dimensions 700mm ×400mm in plan and 500 mm high. The minimum tank size required to be 5 times the width or breadth of footing whichever was more. The bulging effect was counteracted by providing sufficient thick tank. 3-D view of laboratory test tank is shown in Fig.2

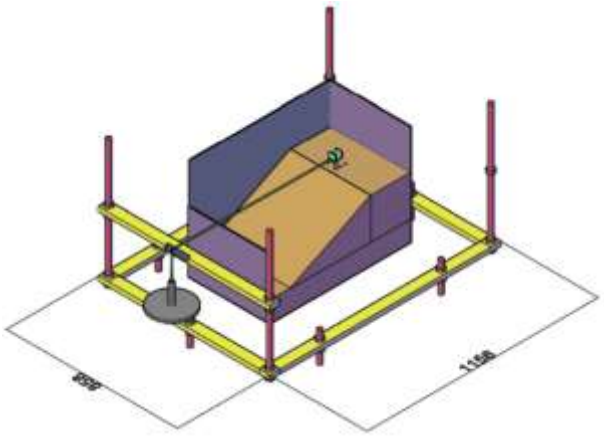


Figure 2: 3D View of Test Tank

3.8 Test Programme

An experimental program was carried out to evaluate the effects of lateral behaviour of a pile located near to the slope crest. Soil samples were constructed in layers by controlled pouring and tamping technique with the bed level and slope observed through the front glass wall. 400 mm in height model slopes was constructed with a minimum depth of sand below the base of the model pile of 100 mm >(5D) to minimize the influence of tank base. The inner faces of the tank was marked at 50 mm intervals to facilitate accurate preparation of the sand bed in layers. On reaching the level of pile base, the pile will be placed on position and is held vertical using special clamp and a layer of sand is poured and tamped. Great care was given to level the slope face using special rulers so that the relative density of the top surface was not affected. Finally, the lateral load was applied incrementally until reaching failure. Each load increment was maintained constant until the pile lateral deflection had stabilized.

All tests were conducted with an artificially made slope of 1V:2H. The pile displacements was measured using two 50 mm travel dial gauges accurate to 0.01 mm placed at two different positions along the length of the pile above the soil surface. Pile rotations slopes at the point of load application was calculated as the ratio of the difference of the two dial gauge readings to the vertical distance between the two measurement points. The details of parametric study are given in Table 2

Table 2: Details of Parametric Study

Sr. No.	Parameters	Details of parameter
1	No. Of piles	1
2	Location of pile	2.5D, 5D & 7.5D
3	Dia. Of pile	10mm
4	Length of pile	10D
5	Loading condition	Inclined
6	Slope	1v : 2h
7	Tank dimensions	0.7m X 0.4m X 0.5m
8	Roughness of pile	Rough
9	Inclination angle	0°,15°& 30°

4. RESULTS AND DISCUSSION

The load vs lateral deflection behaviour of model piled is determined by conducting a lateral load tests on short pile of L/D=10. The safe lateral load capacity of pile footing is decided with the help of IS 2911(1985).

The experimental results that lateral load capacity increases as the distance of pile from slope crest.

The lateral test was conducted on 10 mm pile. The load and corresponding deflection was recorded. Fig.3, Fig.4 and Fig.5 shows the load deflection curve for 10mm diameter pile, at distance of b=2.5cm, 5cm and 7.5cm for 0°, 15° and 30° inclinations.

The lateral safe load was decided from load at which 5mm deflection was occurred. The lateral safe load capacity was observed to be shown in Table 3

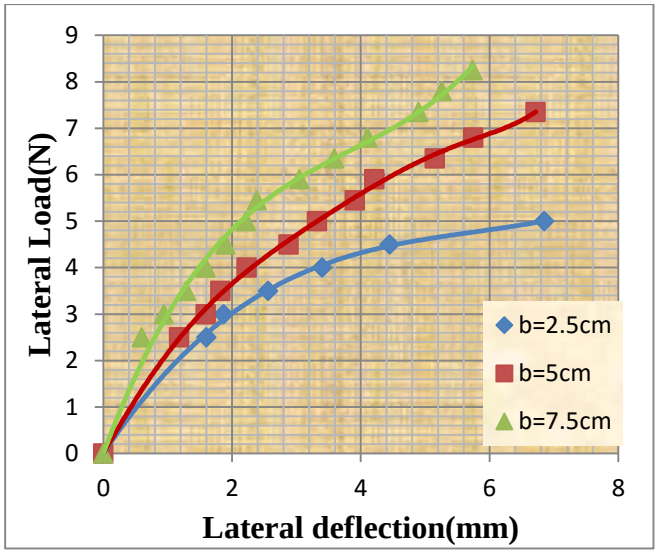


Figure 3: Lateral Load vs Lateral deflection of short pile for 0° of inclination

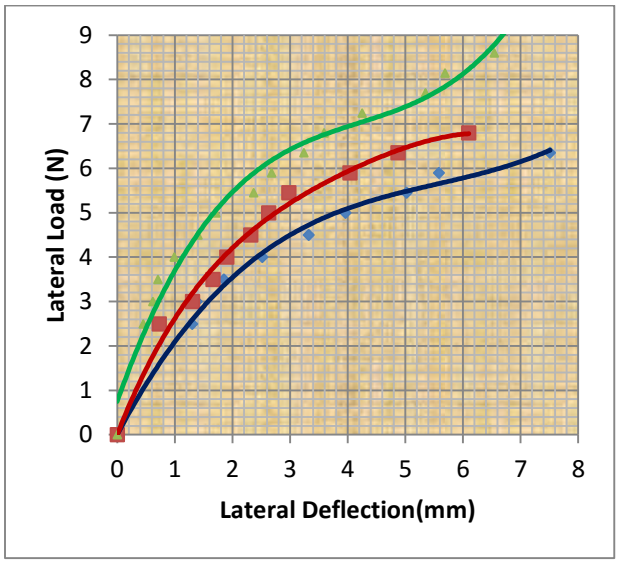


Figure 4: Lateral Load vs Lateral deflection of short pile for 15° of inclination

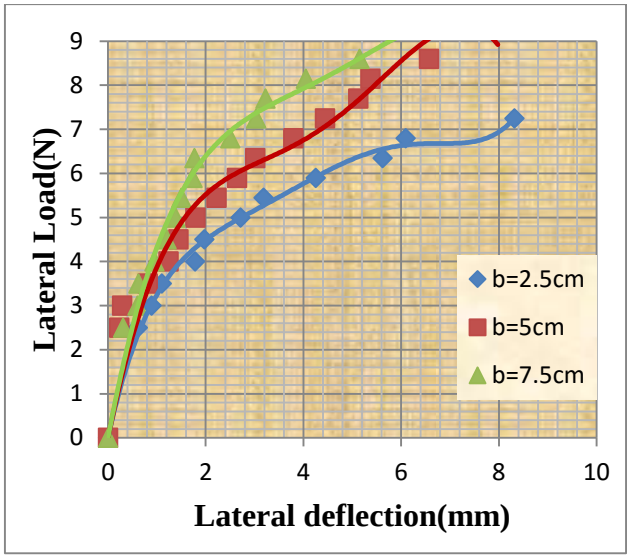
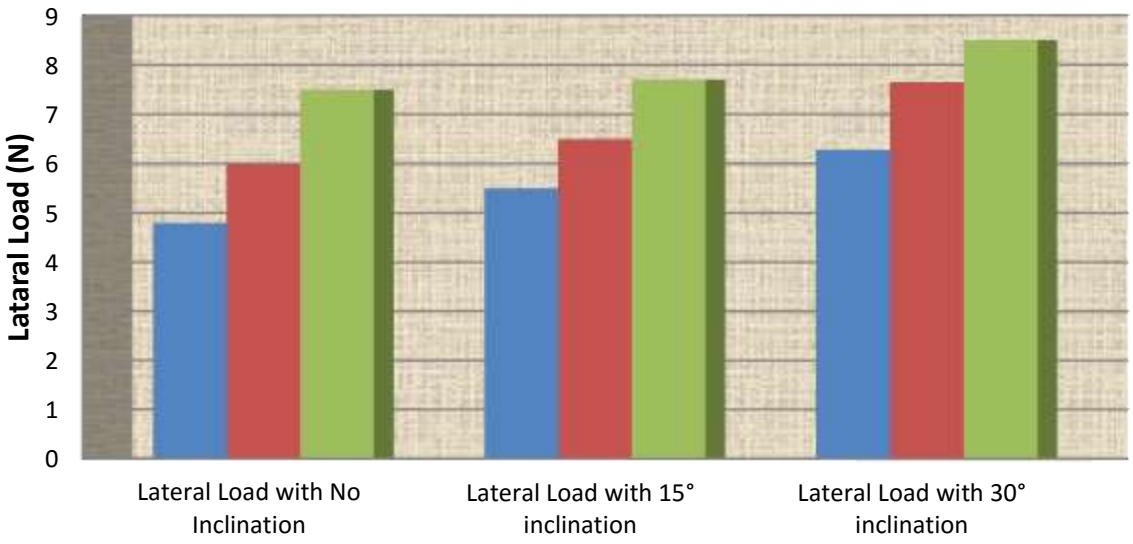


Figure 5: Lateral Load vs Lateral deflection of short pile for 30° of inclination

Table 3: Comparison of Tests (From Bar Chart)



	Lateral Load with No Inclination	Lateral Load with 15° inclination	Lateral Load with 30° inclination
b= 2.5cm	4.8	5.5	6.28
b= 5.0cm	6	6.5	7.65
b= 7.5cm	7.5	7.7	8.5

5. CONCLUDING REMARKS

The improvement in lateral capacity depends on the embedment depth, location of pile, magnitude of force, and the direction of force. The improvement in lateral capacity is found to be more with lateral loading with more inclination. The improvement in lateral capacity is observed with location of pile placed away from the crest of the slope.

Further study is required to determine the lateral loading with considering the reinforcement effect.

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