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Evaluation of Ultimate Behavior of Cement Fly Ash Gravel Pile in Soft Silty Clay by Lateral Loading Test

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***Abstract*- CEMENT FLYASH, GRAVEL (CFG) pile is a useful method for increasing soft soil ground bearing capacity. Nowadays ground improvement is a significant prerequisite in current industry development for land recovery is ending progressively. Present study laboratory tests were conducted on CFG pile with 40, 60 and 90 mm diameter and length to diameter 3 and 4. A Lateral load was applied to investigate the ultimate bearing capacity behavior of the CFG pile. The main objective of this experimental investigation was to study the performance of a single CFG pile under lateral load in silty clay. An experimental result shows that lateral load-carrying capacity was increased by increasing the diameter of the pile. However, bending or ultimate lateral carrying capacities were remained less impact with infusing the higher L/D ratio of CFG pile.**

***Index terms*- Cement Flyash Gravel CFG pile, combined load, Ground improvement, soft Silt.**

1.INTRODUCTION

The rapid growth of infrastructure and industrial development are in urban and ruler area of many countries. Many industries are facing the problem of ground improvement techniques. They are compulsory for soft soil, problematic soil and low enhancing the bearing capacity of the ground. Cement, fly ash, gravel CFG piles are one of the best techniques of the ground improvement techniques. Now recent year many researchers have work on the study of the behavior of CFG pile under different condition loading conditions. Determine the vertical settlement and lateral deformation [1]. Several analytical, experimental, and numerical studies have been conducted on CFG pile-supported embankments over soft soil.[2]; [3]. The CFG pile performed to reducing the vertical settlement and lateral displacement based on the stress concentration ration in soil by experimental [4]. They are significantly moderate in the adoption of static as well as dynamic loads transfer. In china CFG piles foundation used for much high-speed railway projects [5][6][1]. Many of them also worked on the parametric effect of CFG pile by Numerical analysis or FEM approach [7] because it has advantages to easy construction, installation and low cost[8]. Most of the laboratory model test study of the pile embedded in the sand. Few studies concentrate on study lateral behaviors cast pile, especially in silt clay.

The literature on experimental studies exclusive on the CFG model pile in silt clay under the lateral and axial load studies are very limited. The experimental set up based on the [9] ; [10]; [11] for single pile or stone column techniques.

Normally industrial Soft soils are subjected to the heavy machine load for power plants, liquid tank, complex compression station, loading-unloading platform. CFG pile foundations employed in such an industrial coastal region are subjected to dynamic load rather than static load. CFG Piles foundation is used under tall chimneys, towers, embankment, high rise buildings, high retaining walls, bridges & other concrete elevated structures, etc. in the urban area. The dynamic load affected by wind load on the structure, ocean wave, machinery vibration, and seismic load. Lateral load pile test in one of the good means of estimating the lateral capacity of the pile. CFG pile has a good in axial load caring capacity however CFG Piles are generally used to transmit vertical and lateral loads to the surrounding soil media. When the horizontal component of the load is small in comparison with the vertical load (say, less than 20%), it is generally assumed to be carried by vertical piles and no special provision for the lateral load is made. are normally subjected to high lateral loads. These CFG piles or pile groups should resist not only vertical movements but also lateral movements. Some of the measured like soil stiffness, pile bending moment, lateral pile resonance, pile efficiency, ultimate lateral resistance and allowable settlement under working lateral load are obtained for Lateral pile load test.

2. MATERIAL USED

2.1 Soil Materials

The Silty clay soil sample was collected for this research work from Dahod, Gujarat ruler area region collected 1.5m depth from ground level. The collected soil sample was dried, pulverized and passed through 2 mm sieve. The sieve and Hydrometer analysis were conducted on the collected soil sample. It is presented in Figure 1, as the grain size distribution curve. The specific gravity, Atterberg limit of silty clay were also carried out. The Cu undrained shear strength of soft soil mass was determined by the vane shear test and UCS tests at a laboratory. The water contents slightly more than the plastic limit therefore the consistency index approximately equal to 1. The given soil mass Plasticity index soil was 30 percentages. The summary of the properties of soil mass is given in table 1. The soil was classified as per Unified Soil Classification System (USCS) classification in the category of plasticity silt clay (CL). It is clear that 96 % of passing US Sieve # 200. Soil consists of 30% clay-sized particle and 3.8 % sand-sized particle.

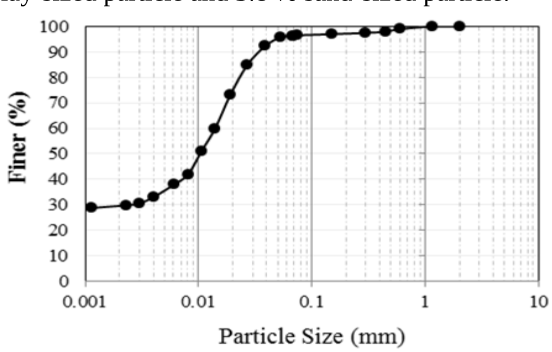

Figure 1: Grain Size distribution of silty clay soil

Table – 1 Property of silty Clay used in the present study

Parameters	Value
Liquid limit (%)	34.00
Plastic limit (%)	04.00
Specific Gravity - G	2.67
Bulk Unit weight (kN/m^3)	18.5
Undrained Shear strength C- (kPa)	10-14
Modulus of elasticity (kPa)	115.0
Maximum dry unit weight ($\gamma_d$max), kN/m^3	19.52
Optimum moisture content (OMC), %	20.00
Passion ratio	0.51
USCS Classification	CL

2.2 CFG Pile

The CFG pile having a diameter of 40, 60 and 90 mm was used. By varying the length to diameter ratio (L/D) of CFG pile was 3 and 4 consider for study the behaviors of semi-rigid pile short pile. The CFG pile by composed to adjust such the amount of cement, fly ash, gravels, sand, and water. The compressive strength of the CFG pile was C- 20 constant in all tests. The testing specimen cement used was 53 grade ordinary Portland cement according to Indian code. The standard sand used in the experiment had an apparent density of 2.64 g/cm3 and a finesse modulus of 2.82. Grade – I fly ash with density 1.55 and a specific area 315 m2/kg was used. The Mixture proposal and details of CFG pile according to the [7]

3. EXPERIMENTAL SETUP

3.1 Soft soil

To achieving shear strength 9- 14 kPa for soft clay bed in all tests according to a molding procedure add 26 % water requirement was added to the silty clay by trial and error. The mixture was initially kept in plastic box 24 hr. for uniformly consistent mixed silty clay. Uniformly mixed clay was placed and hand-packed in the test tank in several layers of 50 mm thickness and was tamped with a template to remove the entrapped air, the silty clay-filled up to 500 mm depth in the tank. This light compaction effect was adopted Moreover the water content is almost constant with depth as well as in the outward direction as adopted.

3.2 CFG pile Insolation

The CFG pile installation method adoption as [12]. The CFG pile of required diameter was properly installed at the center of the tank. A casing pipe with an outer diameter equal to the diameter of the CFG pile was used to install. Moreover, this pipe was pushed gently into the soft silt clay bad up to desire depth. It was ensured that soil had not disturbed during the pipe installation Soft clay inside the pipe was removal by using the hand auger. Then CFG pile mixtures were add in casing pipe. When the casing pipe is pulled out, as per the given process. [12].

3.3 Test set up and instrumentations

In common laboratory experimental practice, the shape of a test tank consists of either a circular or rectangular shape as a boundary. The model test on a circular cylindrical tank with 300 mm diameter, 600 mm height. Fig. 2 shows the schematic details of the experimental setup. In order to measure the response of CFG Pile to applied lateral load, some advanced equipment was used. The stain gauge installed at the top of the CFG pile and a linear variable deformation transformer LVDT was used to top deflection. All the experiments conducted at room temperature. The CFG pile diameters used in this model test were 40, 60 and 90 mm.

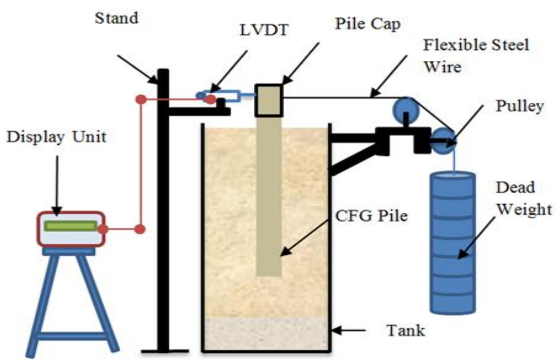

Figure 2: Schematic diagram of the model test.

The static lateral load was applied through dead weights placed on a hanger connected to a flexible steel wire, strung over a pulley supported by a Special arrangement weld with the Tank. It had a fixed during the applied lateral load. Test the CFG pile after 7 days of forming. The load was applied. The pile cap cover was rigidly fixed with the pile and applied the constant rate of 0.05 to 0.1 kN. lateral load. Failure was reached when there was an increase in the pile displacement without the increasing the lateral load or if the displacement was recorded 15 mm. Vertical settlement of pile was also measured by the digital dial gauges positioned at the pile cap for few tests and was found to be nominal reading.

Figure 3: Experimental model set up.

4. RESULTS AND DISCUSSION

CFG Pile top deflection was measured employing linear variable differential transformers (LVDT's) during model lateral load Tests. The arrangement of LVDT is shown in Fig. 3.

Figure 4: Experime

ntal Model Set up.

The deflection was measured at the location of the applied lateral force. A two LVDT, positioned 60 mm above the soil level on the CFG pile, measured deflection at that point on the pile. The average reading was measurements to the difference in deflection provides the lateral deflection of the CFG pile at the measuring point of load application. A plot of CFG pile top deflection versus diameter and L/D applied lateral load is shown in Fig. 5, 6 and 7 respectively.

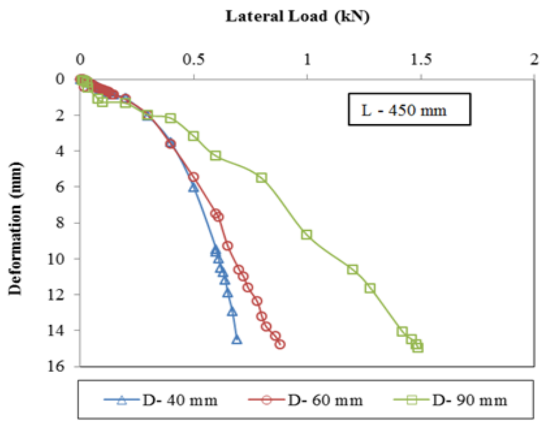

Figure 5: Lateral Load versus deformation curve of CFG pile with variable diameter.

The experimental load-deformation response with three different diameters; 40, 60 and 90 with 450 mm equal length of CFG pile are compared in soft silty clay bed under lateral load is explained in Fig. 5. The lateral load-deformation curve behaviors are non-linear. Moreover, the ultimate and safe lateral load capacity was calculated according to IS 2911- part- 4. The ultimate load-carrying capacity of 40, 60 and 90 mm CFG pile was observed 0.69, 0.88, 1.48 kN while the safe lateral load capacity was calculated 0.50, 0.69, and 1.12 kN respectively, which are 1.27 times and 2.14 times more lateral load-carrying capacity than the minimum diameter (i.e. 40 mm) of CFG pile. The failure paten of CFG pile under the eccentrical load did not observe the strain gauge was imposed only at the top of the pile. It was observed that the ultimate lateral load capacity of the CFG pile significantly increased with the increasing diameter of the pile. In the lateral loading direction, the soil surrounding the CFG pile and above the rotational center is defined as the active zone, whereas other the part from the centerline act under the active zone.

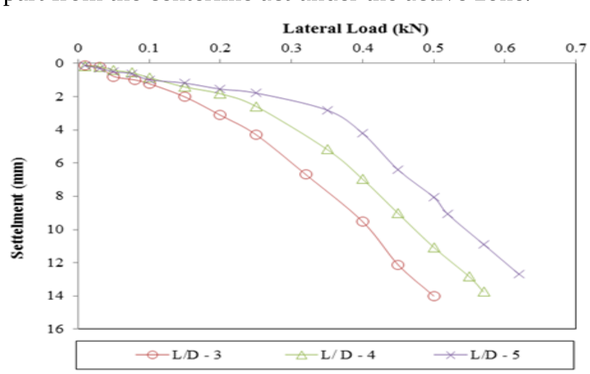

Figure 6: Lateral Load versus displacement curve of 40 mm diameter CFG pile with variable length

The recorded load-displacement curve for three variable-length 120 mm, 160mm and 200 mm [i.e L/D ratio 3, 4, and 5] with a 40 mm diameter CFG pile test are shown in Fig. 6. The curved show that the length of the CFG piles impacts on the ultimate lateral load. The ultimate load was observed at 12 mm displacement. It was observed 0.45, 0.53 and 0.59 respectively. It is clearly explaining that lateral load-carrying capacity of L/D ratio 4 and 5 are 1.17 and 1.31 times higher than L/D ratio 3 CFG pile.

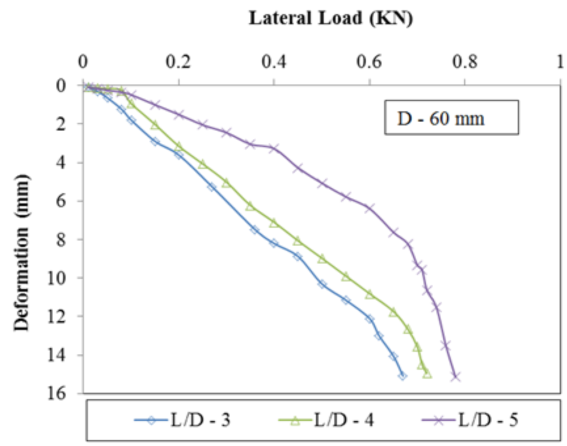

Figure 7 Lateral Load versus displacement curve of 60 mm diameter CFG pile with variable length.

The response of the CFG pile can be presented in applied lateral load and the deformation at the CFG pile head as shown in Fig. 7 show the load-displacement curve for Single CFG pile with a diameter of 60 mm and different lengths [i.e Length/ Depth ratio 3, 4 and 5] consider as short semi-rigid pile. The load-deformation curves are nonlinear behavior. Basically, in this curve L/D ratio 3 and 4 Load-displacement behaviors are near to linearly means displacement linearly effects with load incremental. However, in L/D ratio 5 load-displacement curve behavior is nonlinear. It was observed the nominal incremental lateral load-carrying capacity in the CFG pile. Larger lateral bearing capacity is associated with a larger diameter and larger L/D ratio.

5. CONCLUSION

In this laboratory, experimental research was concluded on different CFG pile to investigate the lateral behaviors of variable diameter and variable length. By considering the test based on the project condition and amount of lateral load-carrying capacity that was necessary, the following conclusion can be drawn:

1. The lateral load-deflection curves are commonly non-linear exclusively for large L/D ratios and large pile diameters. In a shorter L/D ratio, it is near to linear behaviors.
2. The ultimate lateral load caring capacities are 2.14-time increase with increase the diameter 2.25 times. Those explain the ultimate lateral pile capacity increases with the increase in L/D ratio and the increase in the pile diameter.
3. The maximum moment increases with the increase in L/D ratio and the increase in the pile diameter.
4. Larger lateral bearing capacity is associated with a lower loading eccentricity because it affected work- hardening behaviors of CFG pile.
5. The failure patent occurs at a depth varying from approximate 3D (D- diameter of the pile) Length of CFG pile from the point of eccentrically loads.

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