LOAD-SETTLEMENT CHARACTERISTICS OF EXPANSIVE SOILS TREATED WITH FLY ASH COLUMNS

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ABSTRACT

Expansive soils are problematic in nature due to its excessive swelling and shrinkage characteristics under varying moisture content. This behavior is attributed due to the presence of clay mineral montmorillonite. This volumetric changes leads to structural damage of various civil engineering structures and their cost of repair is very high. Various techniques like soil replacement, pre-wetting, under reamed piles, lime-soil columns, surcharge loading, thermal methods are generally used to stabilize expansive soils. Chemical stabilization using lime, cement and fly ash have also given satisfactory results. Fly ash is a product obtained from flue gases of furnace, collected by electrostatic precipitators. The composition of fly ash varies depending on the source and type of coal burnt. Disposal of fly ash is a problem because it is produced in abundant quantities. In this present experimental work, model plate load tests were performed on expansive clay beds in which fly ash was introduced as compacted columns. The fly ash columns were kept floating 100 mm above the base plate. The diameter (d) and length (l) of the columns was kept 40mm and 400mm respectively (L/D=10). A casing pipe was kept vertically at the center of the tank with diameter equal to that of fly ash column. Oven dried fly ash at OMC was poured in the casing pipe and was compacted at its dry unit weight in 8 layers of 50mm each. The casing pipe was gradually withdrawn during the process of compaction. In case of twin columns, the center-to-center spacing between the columns was kept 60mm (S=1.5D) as per JGJ 79-2012 Technical code for Ground treatment of buildings. Load-settlement characteristics of expansive clay improved when fly ash was introduced in the form of columns.

Keyword : - *Expansive soil, Fly ash column, swelling and shrinkage, load-settlement characteristics*

1. INTRODUCTION

Expansive soil shows excessive swelling and shrinkage under varying moisture content. These excessive swelling and shrinkage leads to the failure of lightly loaded civil engineering structures. To overcome this problem, various foundation techniques like soil replacement, pre-wetting, under reamed piles, lime-soil columns, surcharge loading, thermal methods have been adopted. Stabilization of expansive soils with various additives like lime, cement, fly ash, CCR have also given satisfactory results. Fly ash is a product obtained from flue gases of furnace, collected by electrostatic precipitators. The composition of fly ash varies depending on the source and type of coal burnt. Disposal of fly ash is a problem because it is produced in abundant quantities. The quantity of fly ash generated per year worldwide was expected to exceed 100 million tons by the year 2000 (Sridharan et al. 1996.) At present it is available in abundant quantities for utilization. It can be used as an alternative to conventional materials in the construction of geotechnical and geo-environmental infrastructures (e.g., Sharma 1996; Cokca 1997.) In the present experimental study, vertical fly ash columns were installed in expansive clay beds to improve the load-settlement characteristics.

2. MATERIALS

2.1 Clay

The expansive soil used for this experimental work was procured from Tapi river, Surat. The soil has a Free swell index of 63.63%. Based on Liquid limit and Plasticity Index (Casagrande's plasticity chart IS:1498-1970) the soil was classified as Clay of high plasticity-CH type. The maximum dry density is 15.40kN/m³ and optimum moisture content is 24.03%. Table 1 shows the index and engineering properties of soil.

Table-1: Index and engineering properties of expansive soil

Parameter	**Value**
Liquid limit, W_L	53.84%
Plastic limit, W_P	23.57%
Shrinkage limit, W_S	18.11%
Plasticity Index I_P	30.27%
IS Classification	CH
Specific gravity, G	2.66
Free swell index	63.63%
Max. Dry Density (kN/m³)	15.40
Optimum moisture content (%)	24.03

2.2 Fly ash

The Fly Ash used for this experimental work was procured from Torrent Power Plant, Sabarmati, Ahmedabad, India. The optimum moisture content is 18.10% and maximum dry density is 16.28kN/m³. Table 2 shows the index and engineering properties of Fly ash.

Table-2: Index and engineering properties of fly ash

Parameter	**Value**
Liquid limit, W_L	-
Plastic limit, W_P	-
Shrinkage limit, W_S	-
Plasticity Index I_P	NP
Specific gravity, G	1.64
Free swell index	Non swelling
Max. Dry Density (kN/m³)	16.28
Optimum moisture content (%)	18.10

3. TEST SETUP

Model Plate load tests were performed in a split circular steel tank of height 500mm & inside diameter 500mm. Oil was applied on the inner surface of the tank to reduce friction. To carry out the tests on model, the vertical downward load was applied by means of mechanical jack. In this test, to measure vertical downward load intensity, proving ring of required capacity was used. The square mild steel plate having size of 100 mm × 100 mm & 12 mm thick was placed on the top surface of the soil for uniform transfer of load. To measure the settlement two dial gauges were provided at diagonally opposite location.

Figure-1: Setup for model Plate load test

4. TEST PROCEDURE

Model Plate Load tests was performed on untreated expansive soils and expansive soil treated with fly ash columns in order to know the load settlement characteristics. The tests were performed in a tank of inside diameter 500mm and height 500mm. The soil was kept in an air tight container for 24 hours to ensure uniform moisture distribution. Both soil and fly ash were compacted at optimum moisture content and maximum dry unit-weight. The soil was compacted in 10 layers of 50 mm each. The fly ash columns were kept floating 100 mm above the base plate. The diameter (d) and length (l) of the columns was kept 40mm and 400mm respectively (L/D=10). A casing pipe was kept vertically at the center of the tank with outside diameter equal to that of fly ash column (40mm). Oven dried fly ash at OMC was poured in the casing pipe and was compacted at its dry unit weight in 8 layers of 50mm each. The casing pipe was gradually withdrawn during the process of compaction. In case of twin FACs, compaction of columns was done simultaneously in two casing pipes. A square plate of appropriate size 100mm*100mm having thickness 12mm was placed on the top having firm contact with soil material, in order to have uniform transfer of load. Two dial gauges were setup at diagonally opposite locations to measure vertical settlement of soil material. After that, a seating load was applied on the plate using mechanical jack and then the load was applied in multiple uniform increments and maintained till the rate of settlement becomes less than 0.02mm/hour. The average of the readings from the two dial gauges was reported as the footing settlement. For each load increment, settlement was recorded from dial gauges. Models were subjected to a maximum settlement of 25mm. Load v/s settlement graph was then plotted to obtain the load-settlement characteristics of soil material.

Figure- 2: Installation of single and twin fly ash columns

5. RESULT, ANALYSIS AND DISCUSSION

5.1 Load-settlement curve of untreated soil sample

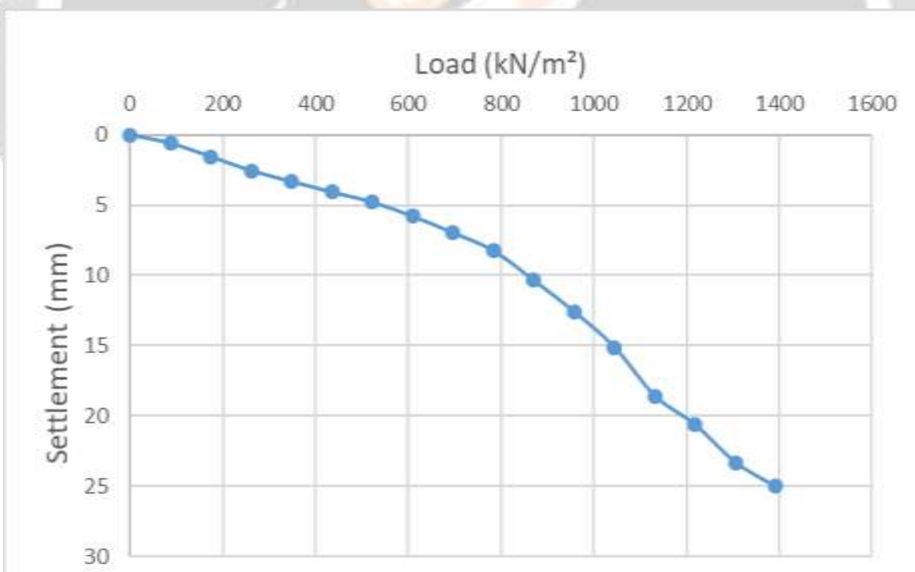

Figure- 3. Load vs settlement curve for untreated soil

5.2 Load-settlement curve of soil sample treated with single fly ash column

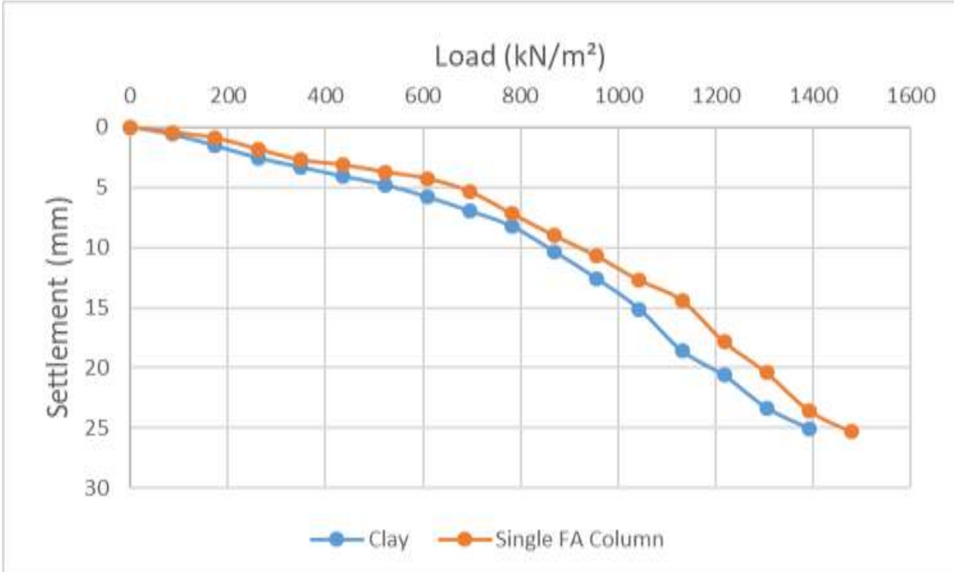

Figure- 4. Load vs settlement curve for soil sample treated with single fly ash column

5.3 Load-settlement curve of soil sample treated with twin fly ash columns

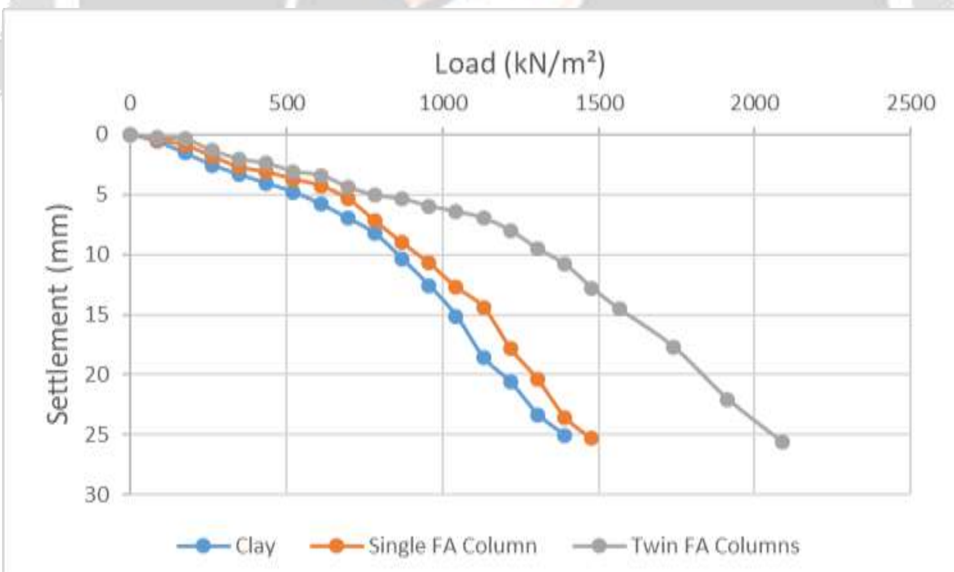

Figure- 5. Load vs settlement curve for soil sample treated with twin fly ash columns

The above figures 3, 4 and 5 shows the load-settlement curves for untreated soil, soil treated with single fly ash column and soil treated with twin fly ash columns. The results pertain to both the soil and fly ash compacted at optimum moisture content and maximum dry unit weight. Soil treated with fly ash columns resulted in an improved load-settlement characteristic as compared to that of untreated soil. The load required for 25mm settlement for untreated soil was 1390kN/m^2, for soil treated with single fly ash column was 1480kN/m^2 and for soil treated with twin fly ash columns was 2090kN/m^2. The percentage strength increment in single FA column and twin FA columns as compared to untreated soil was 6.47%, 50% respectively. Fly ash resisted the applied load better than clay bed alone and resulted in improved load-settlement behaviour.

6. CONCLUSION

- Load-settlement characteristics of FACs-treated expansive clay beds improved in comparison to that of untreated expansive clay beds.
- The load required for a given settlement in FACs-treated expansive clay beds was higher than that required for the same settlement in untreated clay beds.
- The ultimate load at 25 mm settlement for untreated soil was 1390kN/m^2, for single fly ash column was 1480kN/m^2, twin fly ash column was 2090kN/m^2.
- The percentage strength increment as compared to untreated soil for single fly ash column was 6.33%, for twin fly ash column was 50%.
- As the number of FACs in the clay bed increased, load-settlement characteristics further improved.

7. REFERENCES

[1] Sridharan, A., Pandian, N. S., and Rajasekhar, C. (1996). ‘‘Geotechnical characterization of pond ash.’’ Proc., Conf. on Ash Ponds and Ash Disposal Systems, Indian Inst. of Technology, New Delhi, India, 97–110.

[2] Sharma, R. S. (1996). ‘‘Geoenvironmental aspects of fly ash utilization and disposal.’’ Proc., Conf. on Ash Ponds and Ash Disposal Systems. Indian Inst. of Technology, New Delhi, India, 347–357.

[3] Cokca, E. (1997). ‘‘Frost susceptibility properties of soma-B fly ash.’’ J. Energy Eng., 123(1), 1–10.

[4] Phanikumar B.R., Mani A.J., Sathiyasheelan S. and Reddy R.P.: Fly ash columns (FAC) as an innovative foundation technique for expansive clay beds, *Geomechanics and Geoengineering: An International Journal*, Vol. 4, No. 3, 183-188, September 2009.

[5] Darikandeh F., Viswanadham B.V.S.: Swell Behavior of Expansive Soils with Stabilized Fly Ash Columns, *Indian Geotechnical Conference IGC2016*, 15-17, December 2016.

[6] Prof. Dr. Palaniappan K.E.A., Mr. Prabhu S.: Improving Soft Clay Soil Using Fly Ash as Material of Column, *International Journal of Engineering Research & Technology (IJERT)* Vol. 2 Issue 4, April - 2013

[7] Dutta S., Mandal J.N.: Model studies on Encased Fly Ash Column-Geocell Composite Systems in soft clay, *American Journal of Hazardous, Toxic and Radioactive waste ASCE, January 2017.*

[8] Phanikumar B.R., Sharma R.S.: Effect of fly ash on engineering properties of Expansive soils, *JOURNAL OF GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING ASCE*, July 2004

[9] Vidhyalakshmi S., Stalin V.K., Palaniappan K.E.A.: Studies on the behaviour of fly ash aggregate as column material in soft clay, *IGC* 2009.

[10] Phanikumar B.R., Sharma R.S., Volume change behaviour of fly ash-stabilized clays, *JOURNAL OF MATERIALS IN CIVIL ENGINEERING ASCE*, 67-74 JANUARY 2007