NUMERICAL ANALYSIS OF GEOSYNTHETIC ENCASED FLY ASH COLUMN IN EXPANSIVE SOIL

[1]Ritakshi Ayare, [2]Shraddha Kokate, [3]Pranali Hubale, [4]Rohan Deshmukh, [5]PriyankaSalunkhe,
[1,2,3] BE final year student, [4]Assistant Professor, [5]Associate Professor
[1]Department of Civil Engineering,
[1]Terna Engineering College, Nerul, Navi Mumbai 400706,Maharashtra,India.

Abstract : This study helps to understand the suitability of geosynthetic encased fly ash column in expansive soil. The study consist of numerical analysis done in PLAXIS 2D software. In this study, comparison between stone column and fly ash column is carried out. Results are compared for fully penetrated and floated column. The effect of encased geotextile and ordinary column with varying l/d ratio for column is thoroughly studied. Load carrying capacity in both horizontal and vertical direction shows improvement due to encased geotextile.

IndexTerms - : Expansive soil, PLAXIS 2D,Stone column, Fly ash column, Geotextile.

1. INTRODUCTION

From the past few decades there has been an increase in infrastructural Development which led to high increase in the prices of land and shortage of suitable land for development. Stone columns were used to provide higher bearing capacity, reduce settlements, speed up the consolidation Settlement reduce the liquefaction potential of cohesion less soils under Seismic loading and to enhance the stability of natural and manmade slopes. . The ground can be improved by many techniques which includes densification through blasting, vibration and compaction, pre-compression, electro-osmosis, drainage, drying, heating, freezing, addition of admixtures including lime and cement, installing of stiffening column several other methods.

Stone are suited for improving the undrained shear strengths ranging from about 15kpa below. This strength the natural soil is not able to provide sufficient lateral confinement and thus the soil will fail in in. It may be noted that in published case studies indicate the stone column have been used in soil with undrained shear strength as low as 6kpa.

Load carrying capacity of the stone column is attributed to fractional properties of soil mass , cohesion and frictional properties of soil surrounding the column, flexibility or rigidity characteristics of the foundation transmitting stresses to the Improved ground and the magnitude of lateral pressure developed in the surrounding soil mass and acting on the sides of the stone column due to interaction between various elements in the system.

2. LITRATURE REVIEW

2.1 General:-

In the previous chapter, need and objectives of the present study are established. In this chapter, a review of literature on fly ash and expansive soils is presented. Fly ash is the most investigated waste material. Expansive soil also known as black cotton soil, cover almost 20% of the geographical land available in India.

2.2 Properties of Material:-

A different approaches are used the properties of material likes Geosynthetic materials, expansive soil, black cotton soil, fly ash and sand. Rajeev bhatia [1] in their study, fly ash has been used as filling material and concrete debris has been used as granular material. Strengthening the fly ash fill with granular piles of construction-concrete debris of two different sizes under a footing of the same size was studied. Mohanty SK, Pradhan PK and Mohanty CR(2018)[10] studied the properties of expansive soil and their proportion rang is 5%to30%.

2.3 laboratory test:-

The laboratory test carried out single stone column, group of seven column, consolidated- drained triaxial compression test, CSMRS for stabilization of expensive soil, odometer test and CBR test.

Lijun Wu et Al.[2018] presents the cement fly ash gravel (CFG) piles are combined with only geogrid were adopt the improvement method to reinforce embankment over completely decomposed granite (CDG) soil. CFG piles carry for embankment perform well on CDG soil. The laboratory test include consolidated- drained triaxial compression test, odometer test, physical properties. A full -scale embankment experiments significant to increase in soil arching and causing by soil consolidation.

2.4 Experimental studies in PLAXIS :-

S. Naseer, M. SarfrazFaiz, S. Iqbal and S. M. Jamil et al.[2019] The studied without fly ash.research at the effects of floating columns in clayey soil with silty deposits by developing small scale laboratory models. A 15-noded triangular mesh was generated using a finite element tool plaxis 2D finite. The considering undrained analysis for soft clayey soil and drained analysis for sand columns. increase the ultimate loading capacity of sand columns. Increase the ultimate loading capacity of soft soils. The axial capacity of sand columns decreases while increasing spacing between columns.

3. METHODOLOGY

The numerical model developed in PLAXIS 2D software was used for understanding the suitability of geosynthetic encased fly ash column. The numerical analysis in PLAXIS 2D software was done for single stone column and Fly Ash column in the tank having dimension of 350 mm diameter and height of the tank was 532 mm and the column was placed at the center of the clay bed and also column was alone loaded axially .The study was done for fully penetrated and floated column for diameter of 100, 76 and 50 mm. Numerical analysis in PLAXIS 2D was done using the properties as given in Table 1.

Table 1. Properties for numerical analysis in PLAXIS 2D

Property	Stone column	Fly ash column	Clay
ϒdry (kN/m3)	16.62	13.60	14.86
ϒsat(kN/m3)	16.62	22.50	14.86
Young's modulus (kPa)	45000	6183	4000
Poisson's ratio	0.3	0.33	0.45
Cohesion (kPa)	5	2.43	30
φ (deg)	43˚	41˚	-
ψ (deg)	10˚	-	-

3.1 Numerical Analysis for Static Loading

Numerical analysis was done for fully penetrated and floated column for both stone column and flyash column. Axisymmetric analysis is done using Mohr-Coulomb's criterion and elastoplastic behavior is consider for stone column, flyash column and soft clay, also the materials posses the drained behavior. The basic axisymmetric finite-element mesh and boundary conditions are used to represent the column, surrounding clay is shown in Fig. 1.It is perform for column having l/d ratio 5.32,7.09 and 10.64. Column was alone axially loaded by static load of 200,300 and 400 kPa.For the encased column the stiffness of geotextile was taken as J=500 kN/m, 750 kN/m and 1000kN/m.

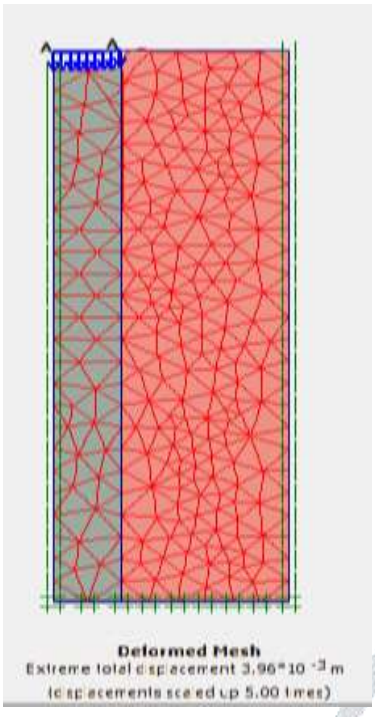


Fig1.Deformed mesh for fully penetrated fly ash column

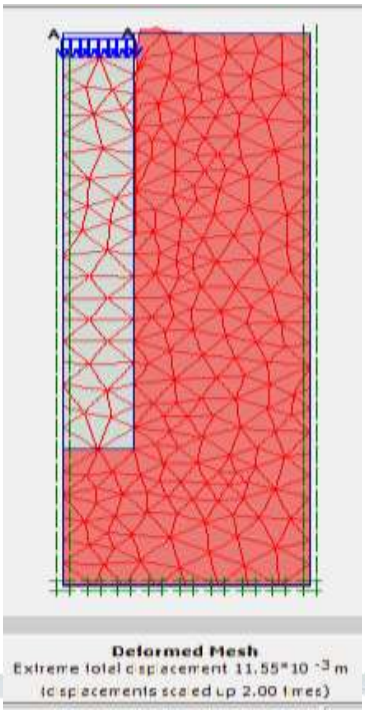


Fig2.Deformed mesh for floated fly ash column

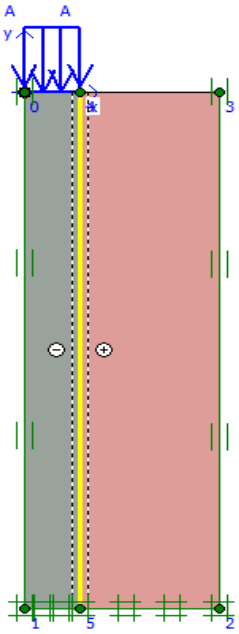


Fig3.boundary conditions for single fly ash column.

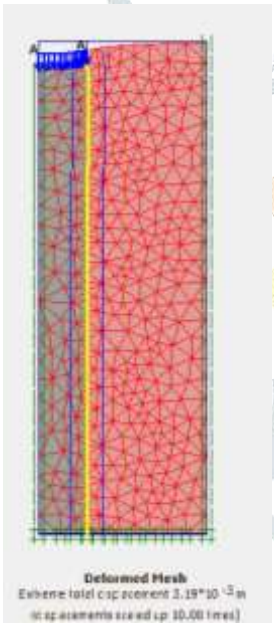


Fig4.deformation of fly ash column after loading

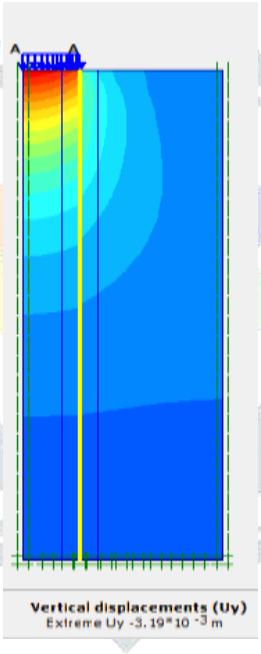


Fig5.Vertical displacement for single fly ash column

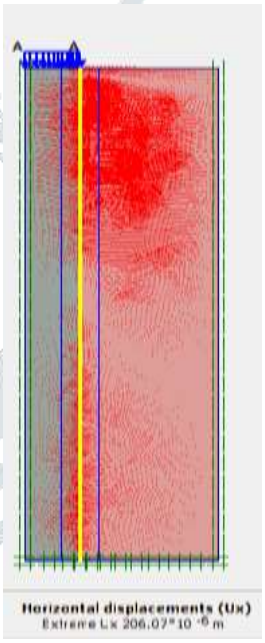


Fig6.horizontal displacement for single fly ash column

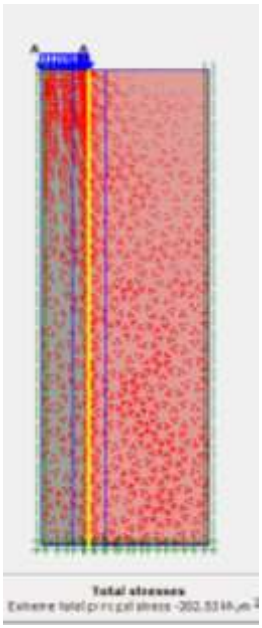


Fig7.Total stresses for single fly ash column

3.2 Numerical Analysis for Cyclic Loading

Numerical analysis is done similar to static loading same parameters are taken for analysis in PLAXIS 2D software. It is perform for column having *l/d* ratio 5.32,7,10.64 for fully penetrated column and l/d ratio of 4,5.26,and 8 for floated column. Column was loaded by cyclic load of 200,300 and 400 kPa. In this total 100 cycles were applied. For the encased column the stiffness of geotextile was taken as *J*=500 kN/m, 750 kN/m and 1000kN/m.

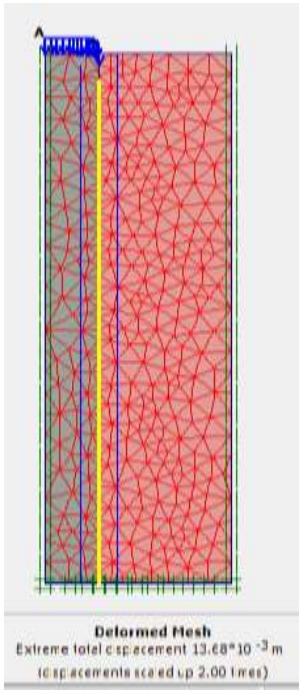


Fig8.deformation of fly ash column after loading

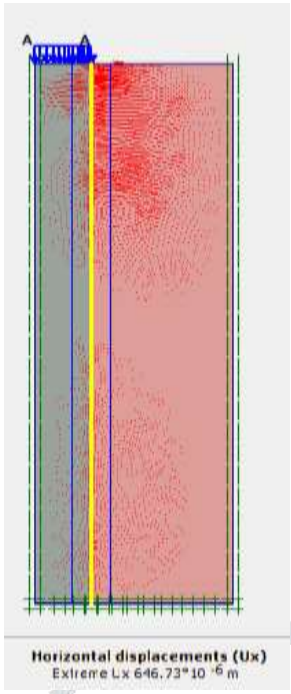


Fig9.horizontal displacement for single fly ash column

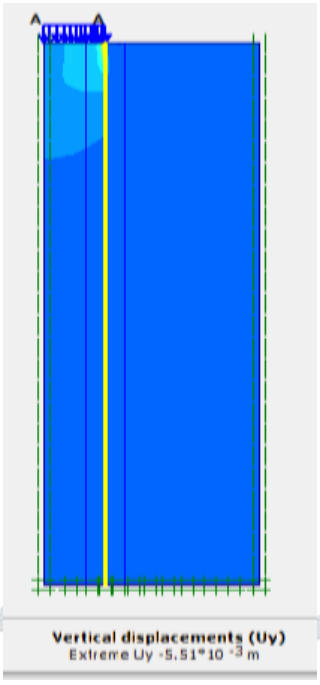


Fig10.Vertical displacement for single fly ash column

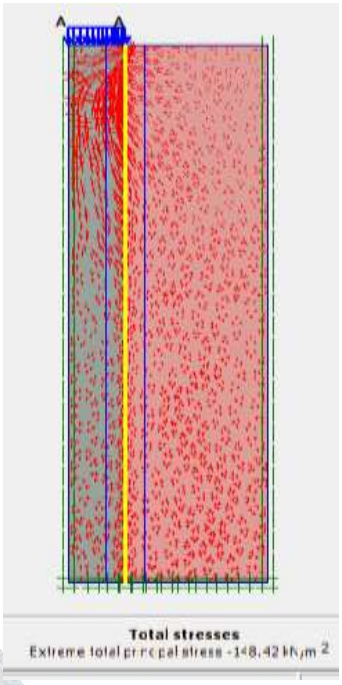


Fig11.Total stresses for single fly ash column

4. RESULT AND DISCUSSION

4.1 Effect of encasement for static loading

Fig 12 and Fig 13 graph shows that there is improvement due to the induced geotextile as compared with the ordinary column. Load applied was 200 kpa on column having *l/d* ratio of 5.32 .Geotextile of full length of 532mm has approximately more improvement than with the geotextile of half length.

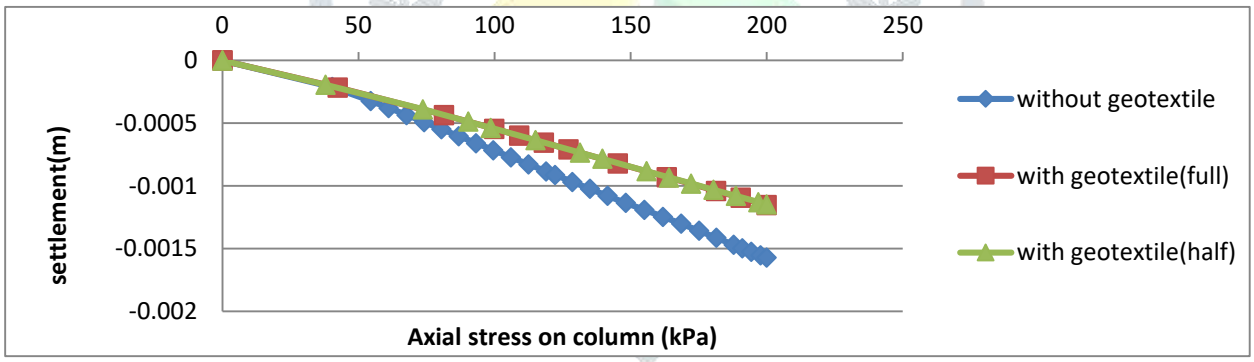


Fig 12. Axial stress on column Vs settlement for fully penetrated stone column

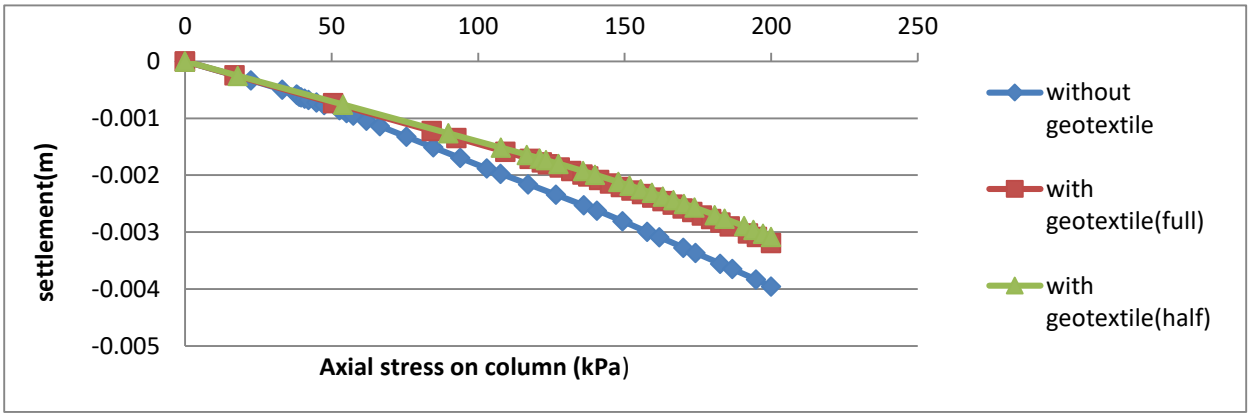


Fig 13. Axial stress on column Vs settlement for fully penetrated fly ash column

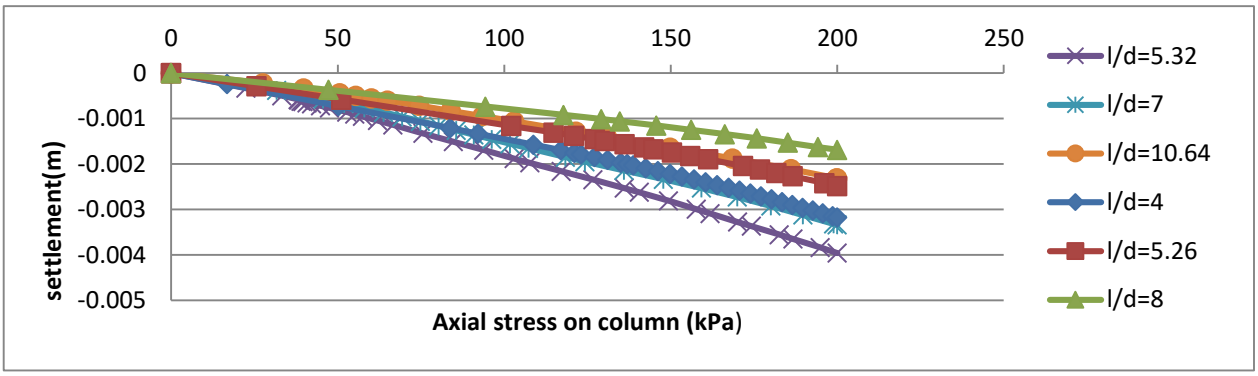
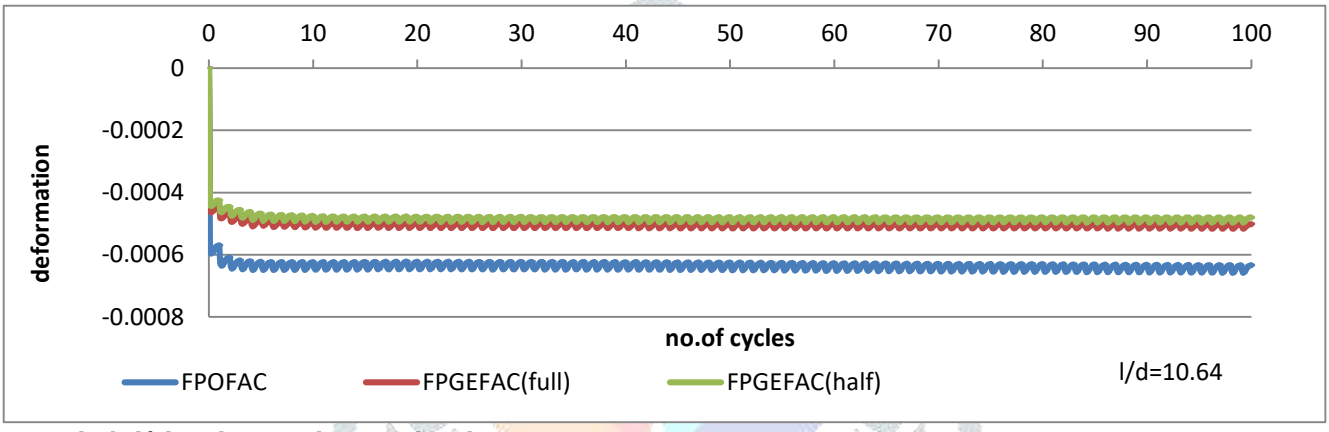


Fig 14.Axial stress on column Vs settlement graph and column is encased by full length geotextile for fly ash column

4.2 Effect of encasement for cyclic loading-

From the graphs it is understood that, ordinary stone and fly ash column shows more deformation as compared with geosynthetic encased columns. Also column with full length encased geotextile shows slightly more deformation than



the half length encased geotextile column.

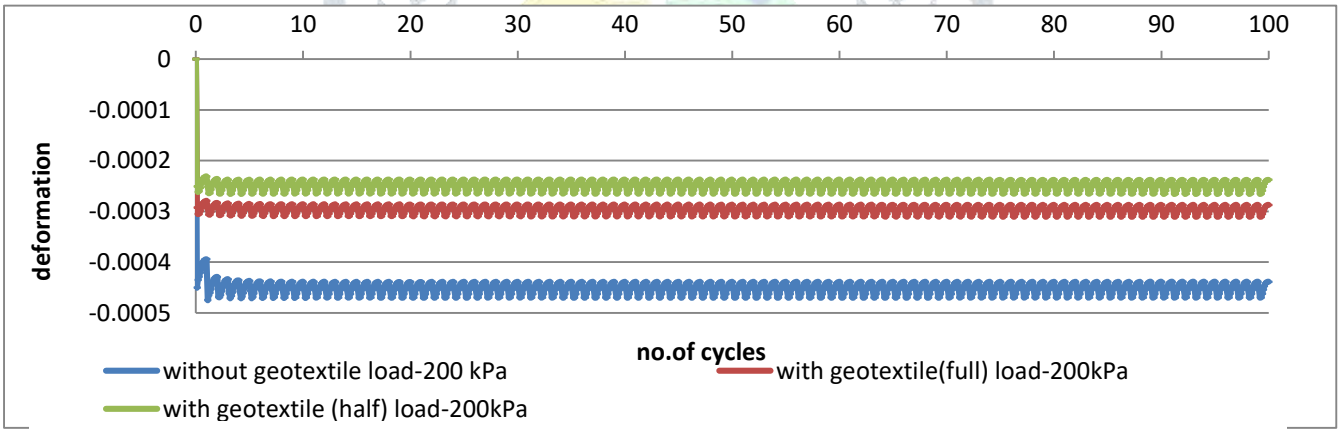


Fig15.Deformation Vs no. of cycles for fully penetrated stone column

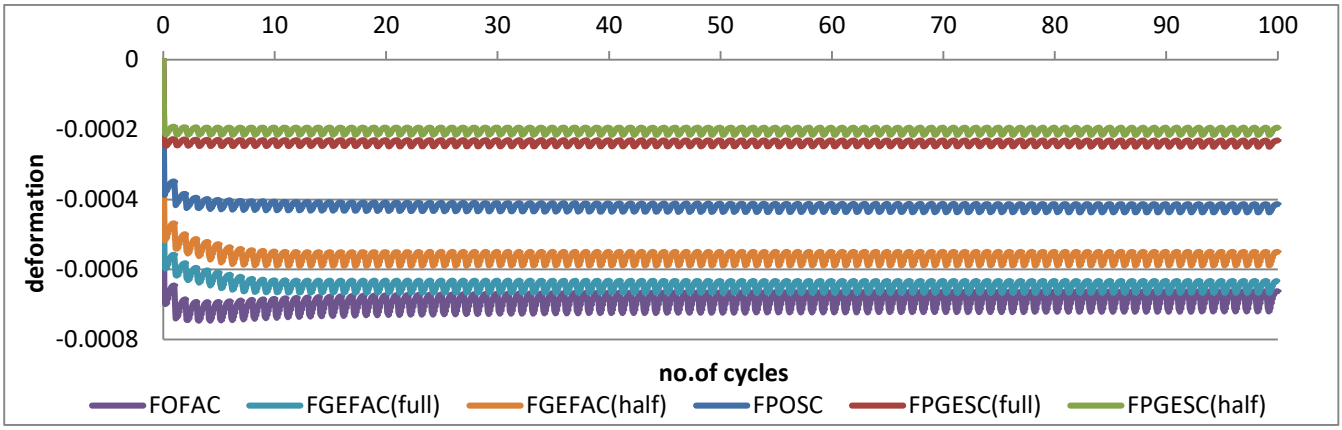


Fig16..Deformation Vs no. of cycles for fully penetrated fly ash column

5. Cost calculation for materials:-

Fly Ash column						Stone column					
Fully penetrated Fly Ash column			Floated Fly Ash column			Fully penetrated stone column			Floated stone column		
Types	D(mm)	cost		D(mm)	cost	Types	D(mm)	cost		D(mm)	cost
OFAC	50 76 100	₹ 0.43 ₹ 0.98 ₹ 1.70	OFAC	50 76 100	₹ 0.32 ₹ 0.74 ₹ 1.28	OSC	50 76 100	₹ 0.69 ₹ 1.60 ₹ 2.78	OSC	50 76 100	₹0.39 ₹ 0.90 ₹ 1.57
GEFAC (full)	50 76 100	₹ 8.78 ₹ 13.68 ₹ 18.41	GEFAC (full)	50 76 100	₹ 6.60 ₹ 10.29 ₹ 13.84	GESC (full)	50 76 100	₹ 8.87 ₹ 13.90 ₹ 18.79	GESC (full)	50 76 100	₹ 6.67 ₹ 10.45 ₹ 14.13
GEFAC (half)	50 76 100	₹ 4.60 ₹ 7.33 ₹ 10.06	GEFAC (half)	50 76 100	₹ 3.46 ₹ 5.51 ₹ 7.56	GESC (half)	50 76 100	₹ 4.70 ₹ 7.55 ₹ 10.43	GESC (half)	50 76 100	₹ 3.53 ₹ 5.68 ₹ 7.85

6. CONCLUSION

1. The geosynthetic encasement of the stone column and fly ash column decreases the load transferred to the clay layer. The overall effect of the encasement is to reduce the settlement of the soft ground.
2. When encasing the column, the lateral bulging is considerably decreased due primarily to the added confinement by the encasement.
3. Static loading on 100mm diameter column shows the displacement for fly ash column as 2-10 times, and for stone column as 5-20 times.
4. Cyclic loading shows 0.5 times displacement for ordinary fly ash column and 2 times displacement for encased fly ash column.
5. Vertical and horizontal displacement is reduced for geosynthetic encased column as compared to ordinary column.
6. Ordinary Fly Ash column shows less improvement of soil as compared with ordinary stone column.
7. Geosynthetic encased fly ash columns shows same result as ordinary stone column.
8. Cost of fly ash column materials is less than stone column materials by 2-3%.
9. So from this it can be concluded that fly ash column construction cost is less than stone column.

REFERENCES

[1] Bhatia Rajeev and Kumar Arvind, Aff.M.ASCE,(2020),"Load-Settlement Behavior of Concrete Debris Pile in Fly Ash Fill." Journal of Hazardous, Toxic, and radioactive waste volume 24.

[2] Orekanti Eswara Reddy and Dommaraju Guruprasad Verma,(2019),"Load- Settlement Response of Geotextile Encased Laterally Reinforced Granular Piles in Expansive Soil Under Compression." International Journal of Geosynthetics and Ground Engineering 5, no.17.

[3] Wu Lijun,(2018),"Performance of Geosynthetic-Reinforced and Cement-FlyAsh-Gravel Pile-Supported Embankments over Completely Decomposed Granite Soil: A Case Study." Advances in Material Science and Engineering;1-11.

[4] Basack Sudip, Ph.D., M.ASCE; Indraratna Buddhima, Ph.D., F.ASCE and RujikiatkamjornCholachat, Ph.D., M.ASCE.(2016), "Modeling the Performance of Stone Column–Reinforced Soft Ground under Static and Cyclic Loads." Journal of Geotechnical and Geoenvironmental Engineering ,volume 142.

[5] Parimala B Indrani ,Ganesh B ,Dr. Chitra R and Shahidnoor,(2017),"Stabilization of Expansive Soil Using Fly Ash and Lime." International Journal of Current Engineering and Scientific Reasearch (LJCSER) Volume 4.

[6] Indiramma P,SudharaniCh and Needhidasan S.(2020)"Utilization of fly ash and lime to stabilize the expansive soil and to sustain pollution free environment – An experimental study." Materials Today: Proceedings volume 22(part 3).

[7] Jayarajan Jayapal and KarpurapuRajagopal.(2019),"Settlement analysis of geosynthetic encased granular column treated soft clay deposits." International Journal of Geotechnical Engineering.

[8] Naseer S,Faiz M. Sarfraz, Iqbal S and Jamil S. M, (2019), "Laboratory and numerical based analysis of foating sand columns in clayey soil." International Journal of Geo- Engineering 10, no.10.

[9] Jose Jerin, Jose Ashika, Kurian Jaise Mary, Francis K Jose and James Sanju K(2018),"Stabilization of Expensive Soil using fly ash." International Research Journal of Engineering and Technology (IRJET) , Volume.

[10] Mohanty SK, Pradhan PK and Mohanty CR,(2018), " Stabilization of Expansive Soil Using Industrial Waste: Fly Ash." Civil Engineering Reasearch journal, Volume 03.

[11] Hosseinpour Iman, Soriano Cristian and Almeida Marcio S.S. (2019),"A comparative study for the performance of encased granular columns." Journal of Rock Mechanics and Geotechnical Engineering, Volume 11.

[12] Ambily A. P., Ph.D.and Gandhi Shailesh R. (2007)," Behavior of Stone Columns Based on Experimental and FEM Analysis. " Journal of Geotechnical and Geoenvironmental Engineering ,volume 133.

[13] Yoo hungsik, A.M.ASCE. (2010), "Performance of Geosynthetic-Encased Stone Columns in Embankment Construction: Numerical Investigation." Journal of Geotechnical and Geoenvironmental Engineering 136(8) 1148-1160.