International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 10, October - 2013

Experimental Investigation Of Stone Column In Shedi Soil

Gavisiddesh Majjagi[1] Santosh G Hiremath[2]

Mtech student[1],Assistant proffesor[2],Department of civil engineering, Basaveshwar Engineering College Bagalkot

ABSTRACT—*in the present study, effect of installation of stone column in shedi soil is done. The study is done with entire area loading (both stone column and surrounding area is loaded), stone column alone (loading only stone column) were carried out for two different lengths to diameter (L/D) ratios. Then in another trial geofabric was used to encapsulate the stone column and then same trials as mentioned above were carried out. Similarly to study stone column in groups, they were tested for different spacing to diameter (S/D) ratios, along with different L/D ratios keeping the diameter of stone column and number of stone columns in group constant only the spacing between the columns was varied*.

1. Introduction

One of the techniques extensively used in soft soils is vibro-replacement, which consists of replacing some of the soft soil with crushed rock or gravel to form an array of stone columns beneath the foundation. An axial load applied at the top of a single stone column produces a large bulge to a depth of 2 to 3 times the diameters beneath the surface [1]. This bulge, in turn, increases the lateral stress within the clay which provides additional confinement for the stone. At equilibrium state, vertical movement reduces compared to that of the unimproved soil. Stone column in groups loaded over the entire area undergoes less bulging than for a single stone column [2]. Stone columns are ideally suited for improving grounds with soft silts, clays and loose silty sands [3]. . In present work reinforcement material is encapsulated for whole length of stone column and is tested for different L/D ratios. Shedi soils are commonly found in south-west coastal belt in India. These soils typically exhibit moderate to high plasticity, low to moderate strength . In India, such soils are usually found in coastal regions from Goa to Cochin

In the present experimental study, stone column with entire area loading, stone column alone were carried out for two different lengths to diameter (L/D) ratios. Similarly stone column in groups were tested for different spacing to diameter (S/D) ratios, along with different L/D ratios.

2. Materials used

2a. Soil

Shedi soil is collected from Haliyal road of Dharwad city, Karnataka state with *Latitude* 15° 28' *N* and *Longitude* 75° 1' *E.* The obtained test results are carried out according to IS codes are exclusively given in the below Table respectively.

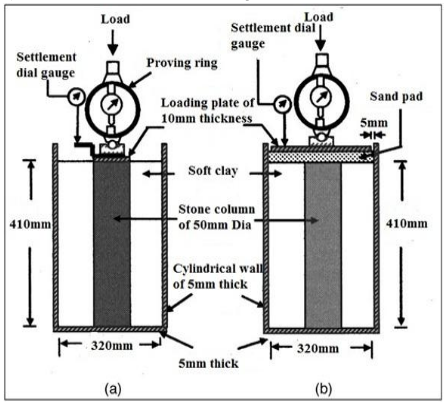
Properties	Shedi soil	IS Codes
Specific gravity, G	2.34	IS 2720 part III/Sec-1, 1980
Atterberg Limits;		
Liquid limit, w_L (%)	49.4	IS 9256-1979
Plastic limit, w_P(%)	27.93	IS2720 partV,1985
Plasticity index, I_P(%)	22.1	
Compaction characteristics;		
Field density,(kN/m^3)	15.31	IS2720 partVIII,1983
Maximum dry density, γ_{dmax} (kN/m^3)	17.46	
Optimum moisture content, W_{OMC} (%)	18.20	
Grain size distribution;		
Gravel and sand (%)	40.84	IS 2720 part IV,1985
Silt & Clay (%)	59.14	
Unconfined compressive strength (kPa)	52.7	IS 2720 partX,1991
Unified classification	CI	
C, kg/cm^2	0.44	IS 3720
Friction angle (φ)	21°	part XI 1993

2b. MODEL FOOTING

A circular plate of 10mm thickness, with varying diameters according to different set up of stone columns was used as prototype footing. For single stone column the area of influence (ie area improved by stone column) considered is 2*D_c. For loading in groups, area of influence is taken as 1.05*S[5]. The details are given in table below and

Schematic presentation of testing

a) Column area loading b)Entire area loading



2c.Reinforcement used

In present work reinforcement material is encapsulated for whole length of stone column and is tested for both the L/D ratios of 4 and 6.1 Uniform stiffness of geosynthetic material is maintained constant throughout all the experiments. Geotextile used in tests are manufactured from high quality polypropylene staple fibres. The material has following properties as mentioned in below tableThe density of the stone column was maintained at 16.8 $kN/m^{3.}$

Properties	Geotextile used - MG200
Mass/unit area	200 gm/mt^2
Thickness	1.6 mm
Tensile strength	6.5 kN/m
Miller burst strength	2100KPa
Grab strength	525N
Elongation	55%
Opening size	150 microns(μ)
U/V stability	70%
Permitivity	1.8/sec

3.Construction of (reinforced, unreinforced and stone column in groups)

Throughout all the experiments a stone column of 50mm diameter and a density of stone column at 16.8kN/m^3 was maintained constant. Stone columns were surrounded by shedi soil in cylindrical Tank-A and Tank-B, to represent the required unit cell , until required settlement is reached .The deformation was measured with help of two

Sizes of plate used as footing is given in below figure

Test type	Diameter of plate in mm
Stone column with entire area loading	100
Stone column area loaded	50
For S/D ratio of 2	110
For S/D ratio of 3	160
For S/D ratio of 4	210

area. All experiments were carried out for two sets of Length/Diameter L/D ratios for 4 and 6.1.Geotextile is the material used as reinforcement. The construction of reinforced stone column is similar to that of plain stone column. The only difference being that during construction, using PVC pipe the geotextile is wrapped around the pipe and then inserted in to the soil bed .In the present study stone columns are installed in an equilateral triangular pattern which gives the densest packing. For an equilateral triangular pattern of stone columns the equivalent circle has an effective diameter of D_e = 1.05 *S Where 'S' is centre to centre spacing between columns Three stone columns were considered for analysis in groups, the loading area was based on IS 15284 where it is 1.05*S for triangular pattern arrangement, it is shown in Fig. 3.15. Three Spacing/Diameter S/D ratios were varied for 2, 3 and 4.In the analysis the diameter of stone column was kept constant and spacing was varied. A five ton calibrated proving ring is used for applying load from five ton capacity screw jack. The loading was done in equal intervals of five divisions

LVDT'S, fixed to tank with help of clamp. Deformation was simultaneously recorded for both

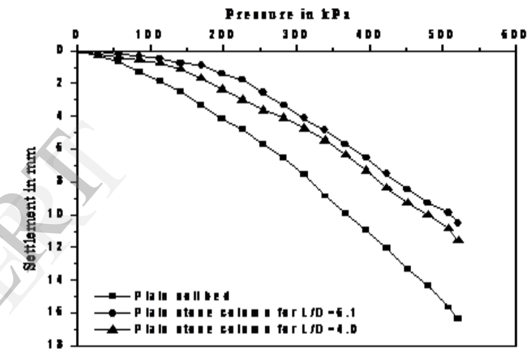
ISSN: 2278-0181
Vol. 2 Issue 10, October - 2013

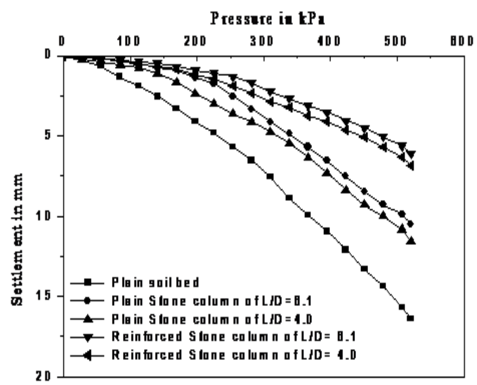
the LVDT'S by alternatively switching the indicator of the recorder. Loading was done until readings were stabilized that is rate of settlement was 0.025mm/minute, and then loading for next stage was carried forward .For all tests area ratio was maintained at 0.250.

4.a. RESULTS FOR ENTIRE AREA LOADING (loading for stonecolumn and surrounding area)

Tests on entire area loading were used to evaluate the improvement in the load bearing capacity of the treated composite ground. The loading of both the stone column and the surrounding equivalent area with confinement of the tank wall represents an actual field condition for the interior columns of a large group of stone columns[4]. When the entire area is loaded, because of the confining effect from the boundary of the unit cell, failure does not take place even for a settlement as high as 10 mm. The ultimate bearing capacity of treated ground was taken as the load intensity corresponds to 10 mm settlement [5]. To know the effect of reinforcement on stone column, it was encapsulated throughout the area of column. Tests were repeated for both the L/D ratios. Figure below shows typical load intensity versus settlement behavior for plain soil bed and improved grounds with the stone column. Figure below shows load intensity versus settlement behavior for plain soil bed and improved grounds with plain stone column and reinforced stone column. The load carrying capacity of untreated ground is based on experimental results on a test tank filled with only the soil of corresponding shear strength and loaded on the entire area.

Description	Load intensity(kPa) for 10mm settlement (Fig.4.2)	
	L/D=4	L/D=6.1
Plain soil	78	78
Plain stone column	121	156
Reinforced stone column	208	277

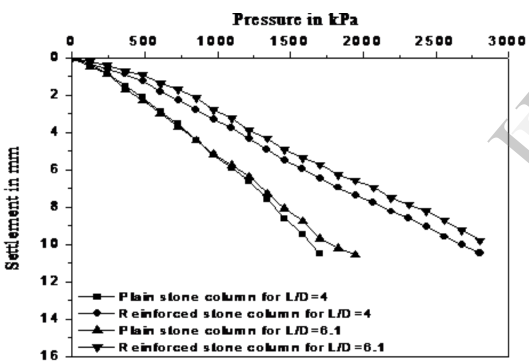


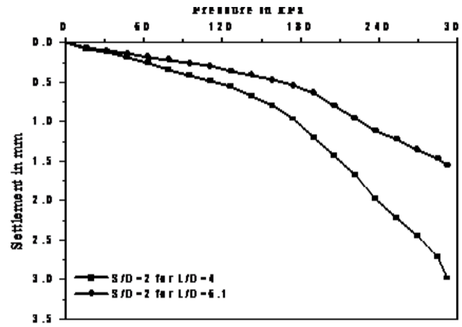


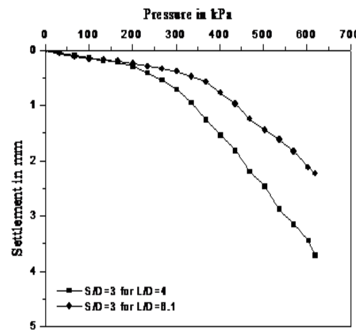
4.b. RESULTS FOR COLUMN AREA LOADING (loading for stonecolumn area only)

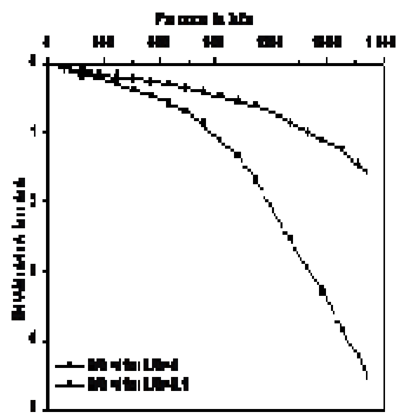
Tests with column area alone loaded were used to find the limiting axial stress on the treated ground. In column area loading, the stone column is loaded up to failure, so as to even study the mode of failures observed in the stone column for different L/D ratios. For L/D ratio of 6.1 the failure occurs by bulging to a depth of 2D, where D is diameter of column. L/D for ratio of 4.0 the failure occurs by punching, which can be observed by distortion at bottom of the stone column. From Fig.4.9 it can be observed that by encapsulating stone column with reinforcement there is decrease in the bulging failure of stone column at the top. Load settlement response of geosynthetic encased stone column generally shows linear behavior not indicating any catastrophic failure, unlike the conventional stone columns.

Description	Ultimate axial stress(kPa) (Fig.4.6)	
	L/D=4	L/D=6.1
Plain stone column	300	350
Reinforced stone column	599	775









4.c

Stone column placed in groups for different spacing to diameter ratios

Description	Stone column in groups for triangular pattern	
	L/D=4	L/D=6.1
S/D=2	238	341
S/D=3	147	176
S/D=4	125	140

5 Failure pattern observed

Mode of failure For L/D ratio of 6.1

Reinforced stone column after test L/D=6.1

Mode of failure for L/D ratio of 4.

6. CONCLUSIONS

In the present thesis, experimental investigations were carried out to determine the influence of on the load carrying capacity of ground treated with plan stone column, reinforced stone column and their behavior when placed in groups. The following conclusions are drawn from this work.

1. Introduction of stone column in soft soil like shedi soil increases its load carrying capacity and reduction of settlement.
2. For single stone column there is increase in load carrying capacity with increase in length to diameter ratio. (i.e. for L/D ratio of 4 it is 55.12% and for 6.1 it is 89.47%)
3. Encapsulation of stone column with geosynthetic material leads to increase in the load carrying capacity when compared to the plain stone column. (ie for L/D ratio of 4 it is 123.3% and for 6.1 it is 197.7%)
4. The geosynthetic material encasement prevents the contamination of stone column and thus will not reduce the friction between clay and stone aggregates.
5. Since bulging of stone column takes place only in upper portion due to lack of lateral pressure, hence providing geosynthetic material in that portion may also be equally important.
6. The optimum spacing to diameter ratio for stone column placed in groups is 2(triangular pattern) for L/D ratio of 4 and 6.1.
7. It is observed that L/D ratios of 4 and 6.1 there is no significant increase in load carrying capacity when S/D ratio is more than 2 in groups.

REFRENCES

[1] Greenwood, D.A.*"Mechanical improvement of soils below ground surfaces". International Proceedings of Ground Engineering Conference*" London, 1970 pg 11–22.

[2] Wood, M.D., Hu, W. and Nash, D.F.T. "*Group effects in stone column foundations: model tests*." Géotechnique, 2000.vol no 50(6): 689-698.

[3] Guetif, Z., Bouassida, M. and Debats, J.M. (2007*). Improved soft clay characteristics due to stone column installation."* Journal of Computers and geotechnics, vol34.2007, pgno104-111.

[4]Ambily, A.P., and Gandhi, S.R. *"Behavior of Stone Columns Based on Experimental and FEM Analysis"*, Journal of Geotechnical and Geoenvironmental Engineering, vol.133, 2006, pp.405-415.

[5]Is 15284 part-1(2003) Design and construction for ground improvements guidelines .

Authors

Gavisiddesh S Majjagi is currently pursuing his Mtech in geotechnical engineering at Basaveshwar Engineering college Bagalkot ,completed his BE in SDM college dharwad in 2008. Has worked 3years in field for various projects including geotechnical investigation for Banglore metro and various reinforced wall projects.

Santosh G Hiremath is working as assistant professor in Basaveshwar Engineering college Bagalkot ,he completed his Mtech in geotechnical engineering in National Institute of technology suatkal(NIT).Along with academic experience he has professional experience and has worked for L&T for 2 years.