PERFORMANCE EVALUATION OF LOAD CARRYING CAPACITY OF STONE COLUMNEMBEDDED IN SOFT SOIL

Shiv Saroop[1], Er. Ankaj Minhas[2], Er. Nasir Ali Lone[3]

[1]M.tech Student in Galaxy Global group of Institutions, Dinarpur, Ambala.

[2, 3]Assistant Professor, Civil Engineering, Galaxy Global group of Institutions, Dinarpur, Ambala.

Abstract: The Use of stone column as a ground improvement technique is of recent origin. Stone columns are extensively used to improve the bearing capacity of poor ground, time rate of settlements, stiffness, shear strength of soil and can also be used to reduce the settlement of structure, liquefaction potential of soft ground. The stone column technique is widely used to strengthen the ground so as to support various geotechnical facilities like embankments, oil tanks on poor ground, low-rise buildings, highway facilities, bridge abutments. The method is generally adopted in clayey soils. Various researchers have worked on stone columns. Many numerical analyses, model tests, field tests, mathematical simulations are carried out to study the effects of stone columns on poor ground. In this study, the strength parameters of stone column are discussed.

Keywords: Soil bearing capacity, Stone column, Deflection, Settlement, Liquefaction.

1.1 INTRODUCTION

Load carrying capacity of a stone column is attributed to frictional properties of the stone mass, cohesion and frictional properties of soils 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. The stone column derives its axial capacity from the passive earth pressure developed due to the bulging effect of the column and increased resistance to lateral deformation under superimposed surcharge load. In recent years, the reinforcement of weak foundation soils with stone columns has expanded a great deal around the world, which allows increase in stability, reduction of settlements, greater speed of execution and reduced cost(5). The lateral pressure and shear stress can be exerted on surrounding clays during the installation of stone columns. Thus accelerate the construction time and improving the load bearing capacity of the foundation soil. The theory of load transfer, estimation of ultimate bearing capacity and prediction of settlement of stone columns was first proposed by several researchers.

1.2 FAILURES OF SOFT SOIL

Geotechnical failures of construction on soft soils in India have occurred in many different ways. These problems have been faced throughout the country. Most of the failures occurred due to negligence, lack of knowledge and lack of data. In some cases the failures have killed many lives and damages many infrastructures. Soft soils can be naturally made and also as a man made product such as tailing materials. Some serious mistakes were caused by unwillingness to cover the cost of safety. Most of the marine deposits are of recent origin and have not undergone much consolidation. As a result, they have low shear strength or high compressibility (2). The construction industry is constantly facing challenges with soft soil deposits. Soft clay deposits have a very low bearing capacity, highly compressible and excessive settlement characteristics. The strength development of soft soil is time dependent. These clay deposits are commonly widespread in the coastal areas and major river valleys, of varying thickness, ranging from 5m to 30m. Following are the various casual factors of failures in soft soil:

1. The slope is too steep.
2. Unsuitability of soil properties
3. Less Compaction
4. Influence of pore water or rain.
5. Earthquake
6. Liquefaction
7. Human Manner

1.3 STONE COLUMN

Stone columns are cylindrical columns made below ground level which comprises of granular material of large size varying from 25 to 100 mm. A hole is made in the soft deposit by different techniques and then filled with stones in layers and compacted to form the complete column. When a structure is placed over the area treated by stone columns, majority of the load (80- 90%) is transmitted to the stone column because of their higher stiffness. Balance 10-20% of the load is taken by clay deposit. With the help of this 10% of surcharge load, the soft clay is able to provide adequate confinement to the cylindrical column. The maximum permissible actual stress on the columns can be predicted from the known theory.

The area treated by stone columns can be used to support only flexible structures such as embankment, oil storage tank, etc. because, the settlement even after treatment with stone column can be large (50-200 mm). Without stone columns the settlement could have been 3-4 times higher and also the bearing capacity would have been much less.

1.4 OBJECTIVES OF THE STUDY

1. To find out the bearing capacity and settlement response of soft soil reinforced with stone columns.
2. Improvement of consolidation behaviour of the soft ground by introducing stone column.
3. To study the performance of stone column treated soft ground,
4. To study the properties of soft soil.

5. To study the improvement of soil by using stone column under footing load test.

1.5 LITERATURE STUDY ON STONE COLUMNS

Hamed Niroumand et al considered in their examination on Soil improvement by strengthened stone sections dependent on exploratory work made an audit on ground improvement for utilizing fortified stone segments in geotechnical building ventures. There was a unique spotlight on the most proficient method to execution and assess ground improvement utilizing strengthened stone section for specific purposes. The past outcomes showed the strengthened stone segments altogether increment the bearing limit and pressure of the dirt. In light of past outcomes, basic qualities were talked about and suggested. The consideration of level cross sections expanded the heap conveying limit of granular segments. The presentation expanded with expanding cross section numbers. It was likewise discovered that flexible materials in the plate structures were the best fortification plan for the granular segments. The geosynthetic encasement counteracts the defilement of stone segment and in this manner won't diminish the rubbing between the stone totals and dirt bed.

H.A Mahamed Ismail et al has done research on Consolidation of sand and total as stone section material. A unit cell is utilized to think about the union under appropriation load for total and sand segment. An ax symmetric union model utilizing PLAXIS programming reenactment is utilized to look at the expanding pace of combination for the two materials. The closed with: Stone segment establishment in delicate muds may improve the dirt trademark. The combination procedure can be assisted when introducing the stone segment. Sand segment is the appropriate material to be utilized as stone segment in quickening the union rate.

Jajatikesharinaik considered in his examination on Load conveying limit of stone sections installed in compacted lake fiery remains, endeavored to evaluate the appropriateness of strengthening strategy by stone segments to improve the heap helping limit of lake powder stores through a few research facility model tests. The shear parameters of the compacted lake cinder tests fortified with stone sections of shifting territory proportions and length proportions are assessed from triaxial pressure test. Furthermore, stone sections having distinctive territory proportions and length proportions are presented in compacted lake fiery debris beds and the bearing limit of the composite framework is assessed through a progression of balance stacking tests. Because of the control and test arranged at higher compactive exertion credited to the closer pressing of particles, bringing about the expanded interlocking among particles. A closer pressing is additionally dependable in expanding the attachment segment and point of interior rubbing in the sample. so that the unit union was expanded from 0.106 kg/cm2 to 0.239 kg/cm2 and edge of inward contact was expanded from 19.870 to 37.40. The UCS tests among all territory proportion and their regarded length proportion of fortified stone sections as expanding of region proportion of strengthened lake fiery debris the pressure worth has diminished with the diminished of strain.

Dipty Sarin Isaac et al studied on the Suitability of various materials for stone segment development. The impact of section material in the exhibition of stone segment is examined through research center trials on model stone segments introduced in mud. The unreinforced soil under a similar stacking condition was broke down. It was discovered that stones are the best stone segment material. Quarry dust, however a waste item is viable in improving the heap misshapening qualities of the dirt utilized. Test study on conduct of gathering of three sections and seven segments was additionally led. A limited component investigation utilizing 15-noded triangular components with the product bundle PLAXIS was likewise completed. Among the distinctive stone segment materials utilized, stones are observed to be progressively successful from single section test and gathering segment test. Quarry dust, however a waste item is viable in improving the heap twisting attributes of the dirt utilized and its exhibition is practically identical with that of sand. Henceforth quarry residue can be financially and viably utilized for stone segment development as it is shabby and effectively accessible. Stress-settlement reaction is anticipated by the limited component technique and discovered coordinating with trial results.

1.6 TESTING OF STONE COLUMN

Load testing of stone columns using footing was adopted so as to apply the load over an area larger than the cross-sectional area of a column. This is because applying the load over an area greater than the stone column increases the vertical and lateral stresses in the surrounding soft soil and it also reflects the insitu condition. The footing load tests on a single as well as on group of three columns, were performed at the trial site to evaluate the load settlement behavior of the stone columns, shear strength of the composite stone column reinforced ground and to verify the adequacy of the overall construction process. The test sites were close to the embankment within 20m away from the edge of the embankment. The initial soil conditions at each of these test sites was established by conducting field vane shear tests at 1.5m intervals in a borehole at each test site. For three-column group, 15 stone columns were constructed in the prescribed pattern and 7 columns for the single column test. For all types of load tests a compacted blanket of 300mm thickness consisting of medium to coarse sand was spread over each test area before commencement of the load tests. A reinforced concrete footing of appropriate size and thickness was constructed on the sand blanket. The diameter of the RCC footing in case of single column was equal to the spacing of stone columns (i.e. 4m) with center of the footing coinciding with the center of the column. In case of three-column test, the diameter of the concrete footing was 1.81 times the spacing of the columns (i.e. 7.3m) with its center coinciding with the center of the three columns laid in a triangular pattern. The test load was corresponding to a pressure intensity of 150 kN/m2 on the footing for single and three-column group, which corresponds to a surcharge load of 1885kN and 6100Kn including self weight of footing for single and group column test respectively. The test load was applied on the stone columns through the footing in stages using enlarge and the arrangement for group testing, test load required huge ken ledge. Also, because of large diameter of footing, about 13 m long girders were employed to support the dead load which was finally supported on the ground over wide area on all the four sides of the test pit.

1.7 TRI AXIAL SHEAR TEST

In a triaxial shear test, stress is applied to a sample of the material being tested in a way which results in stresses along one axis being different from the stresses in perpendicular directions. This is typically achieved by placing the sample between two parallel platens which apply stress in one (usually vertical) direction, and applying fluid pressure to the specimen to apply stress in the perpendicular directions. The application of different compressive stresses in the test apparatus causes shear_stress to develop in the sample the loads can be increased and deflections monitored until failure of the sample. During the test, the surrounding fluid is pressurized, and the stress on the platens is increased until the material in the cylinder fails and forms sliding regions within it, known as shear bands. Soil with various amounts of POND ASH added to determine the effect on shear parameter of soil with 0 % to 24% by dry weight of soil. The results of tri axial shear test is shown in table 5.7 to table 5.10 and figure 5.9 to 5.12

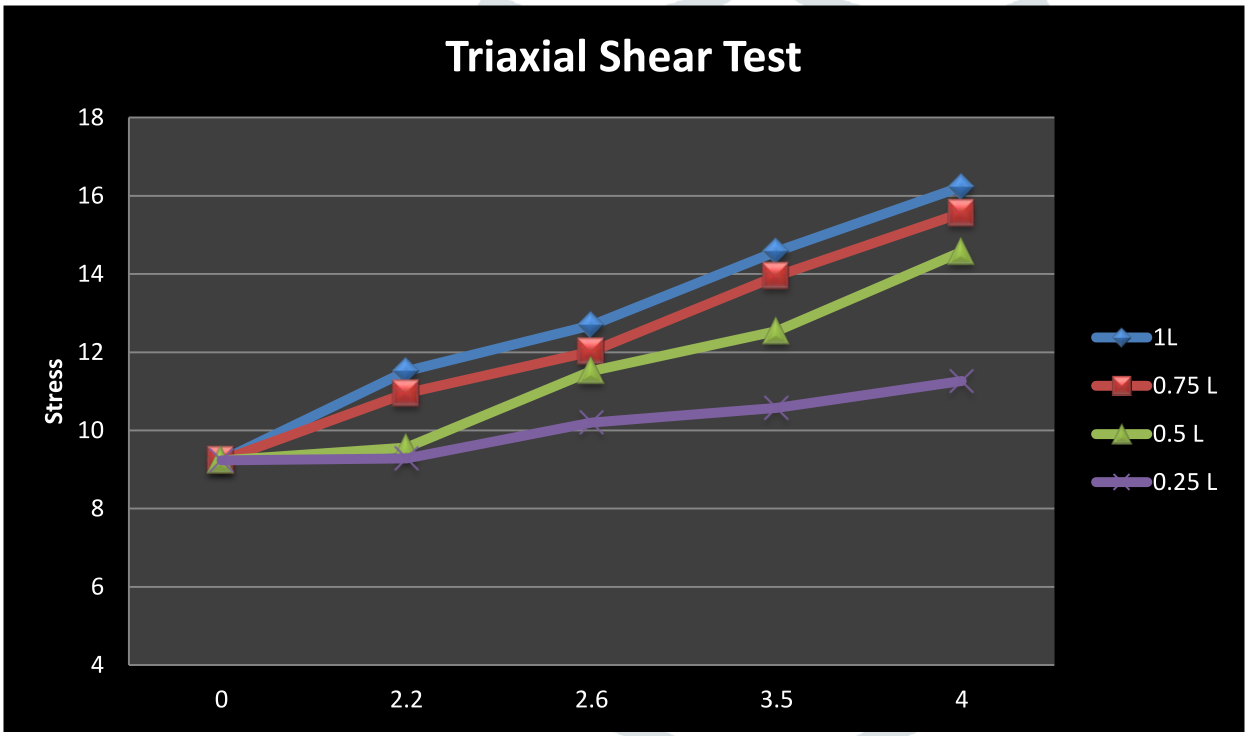

Figure 1: Triaxial shear test results for reinforced pond ash samples with stone column with Confinement Pressure at 3 Kg/m^2

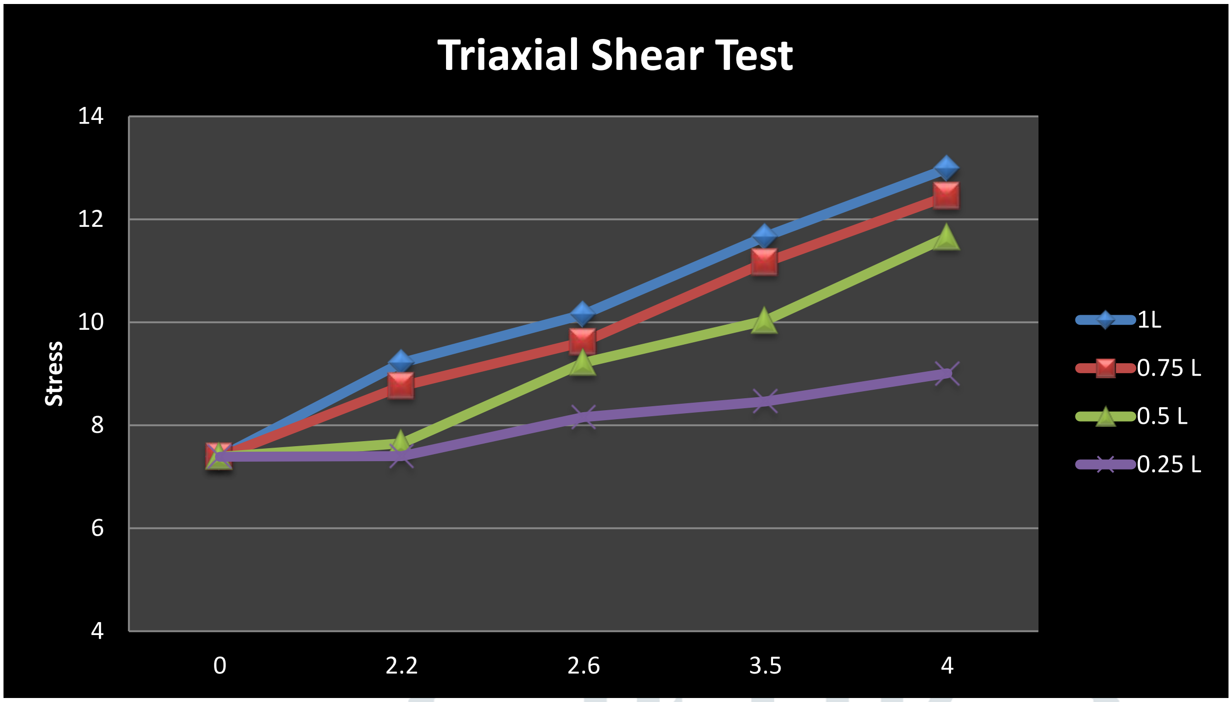

Figure 2: Triaxial shear test results for reinforced pond ash samples with stone column with Confinement Pressure at 2 Kg/m^2

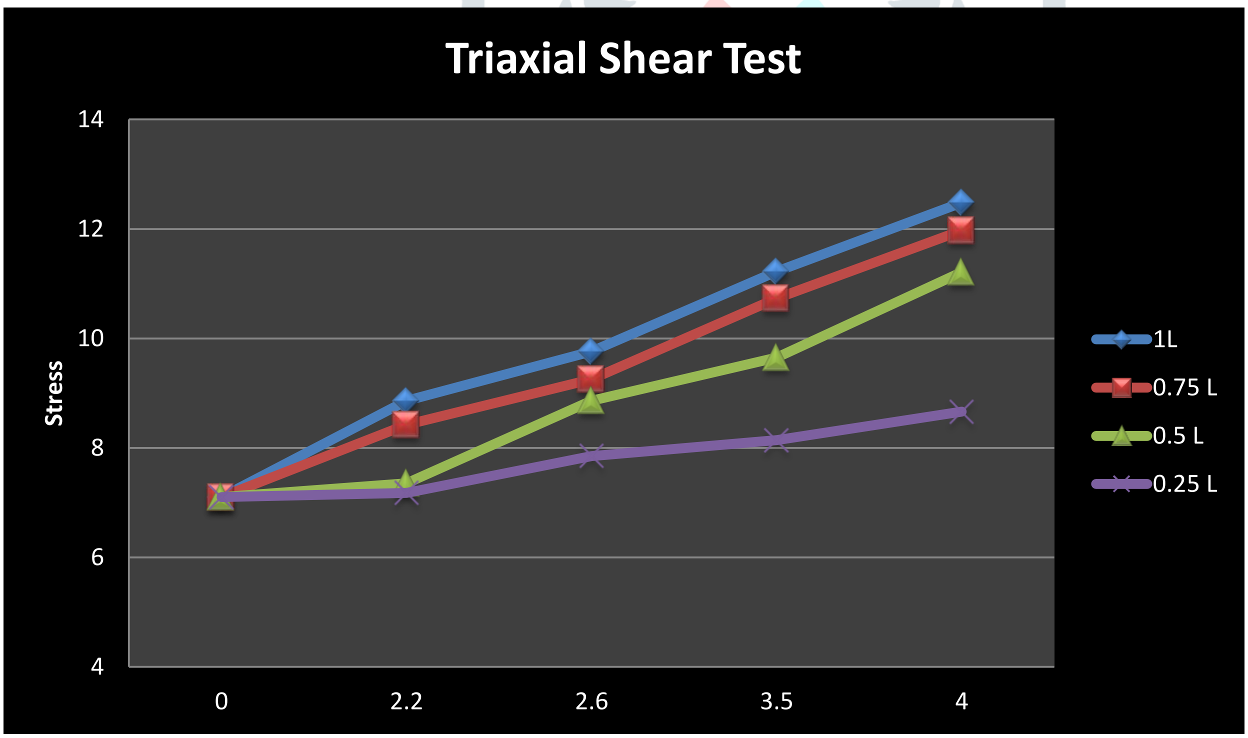

Figure 3: Triaxial shear test results for reinforced pond ash samples with stone column with Confinement Pressure at 1 Kg/m^2

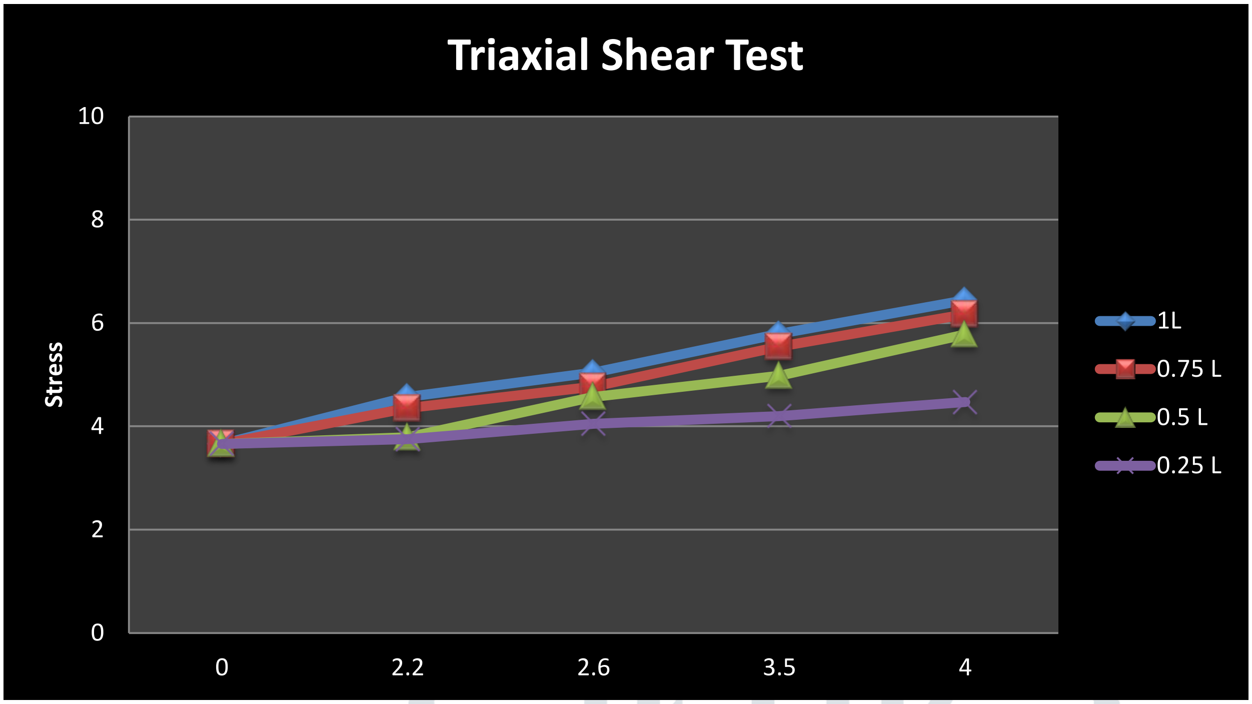

Figure 4: Triaxial shear test results for reinforced pond ash samples with stone column with Confinement Pressure at 0 Kg/m^2

1.8 FOOTING LOAD TEST

Footing load tests were carried out on untreated pond ash specimens compacted to their corresponding MDD and OMC .This test was carried out to study the load settlement behavior of pond ash reinforced with stone column in different length ratio of their respected area ratio and the test result and behavior has given in table 5.11 and figure 5.13. It shows higher stress for higher area ratios. Similarly higher stresses for a particular area ratio were observed for higher length ratios. Because of the higher angle of internal friction it has, stone column plays a major part in increasing the strength of pond ash. From the Fig it is visible that the initial stress is maximum at higher area ratio and for a particular area ratio, the initial stress increases linearly with the increase of length ratio. Also, the maximum failure stress depends on the maximum area ratio and length ratio.

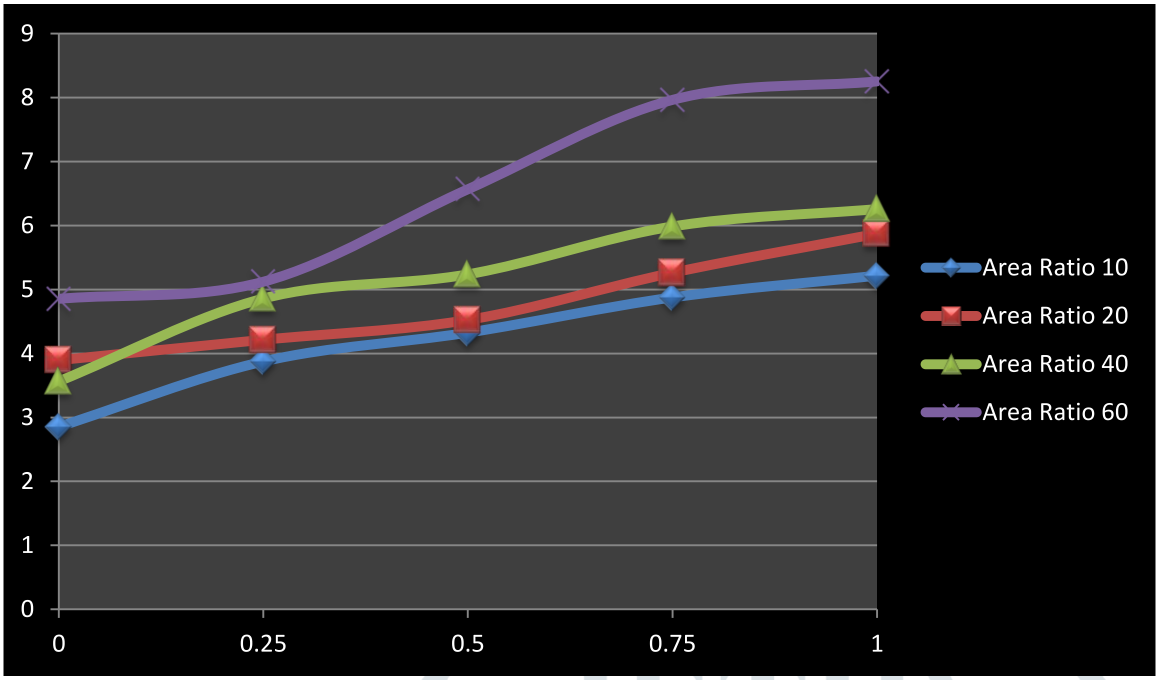

Figure 5: Variation of Bearing Capacity with Length Ratio

CONCLUSION

Different conclusions can be drawn from this study:

1. The triaxial tests in different area ratio of their respected length ratio with different confining pressure, the higher area ratio of their respected length ratio shows maximum stress due to confinement. The stress value was increased by increase of confining pressure. So here due to full length of stone column and confining pressure the stone column show more effective as compare to other because of the closer packing of particles, resulting in the increased interlocking among particles. A closer packing is also responsible in increasing the cohesion component and angle of internal friction in the sample.
2. The initial stress is maximum at higher area ratio and for a particular area ratio, the initial stress increases linearly with the increase of length ratio. Also, the maximum failure stress depends on the maximum area ratio and length ratio. After reaching the maximum failure stress, the failure zone rises to the upper surface of pond ash bed.
3. In the footing load test the failure stress increases linearly with the area ratio. With the decrease in the length ratio, the failure strain is observed to be increasing. This is due to the fact that, for the case of higher length ratio the stone column- having a higher angle of friction and higher density- leads to a lower strain.
4. For the case of low length ratio, the particles of the stone column and the pond ash settle on application of the load. However, since pond ash forms a major portion of the specimen, the strain caused is higher than for the larger length ratios.
5. The price of pond ash is much more than different standard materials for the Soil Stabilization though it may be utilized in locations owning very poor soil as a result of the Shear Strength of its improving property
6. Unstabilized soil sample has a high Atterberg's limits and swelling percentage.
7. The results indicate that with the increase of Pond Ash in the soil sample at 21 % proportion ratio the soil strength is increased and after certain percentages it's getting decrease.
8. Liquid Limit increases, as the percentage of Pond Ash increases.
9. Addition of Pond Ash with soil reduces their plastic indices.

10. Observing the economic cost of its as well as quality of stabilization enhancement, it's apparent this kind of stabilization might be appropriate in gravel soil or perhaps in shoulder part of highways.

REFERNCES

1. S.F. Kwa, "Ground improvement using stone column construction encased with geogrid", Construction of Unique buildings and structures.
2. A. Vahedian, "A Short State-of-the-Art Review on Construction and Settlement of Soft Clay Soil Reinforced with Stone Column", International Journal of Engineering and Technology, Vol. 6, No. 5, October 2014.
3. B. Indraratna, S. Basack, and C. Rujikiatkamjorn, ―Numerical Solution of Stone Column–Improved Soft Soil Considering Arching, Clogging, and Smear Effects, Geotechnical and Geoenvironmental engineering, vol. 139, no.3, pp. 377-394, 2012.
4. D. Sayar and M. Khalilpasha, ―Soil Improvement Using Vibro Replacement Technique, International Journal of Advances in Environmental Biology, vol. 6, no.2, 658-661, 2012.
5. U. Kumar, Y. Tandel, and C. Solanki, ―Effect of geosynthetic encasement on sand column in soft soil, Structural and Civil Engineering Research, vol. 2, no. 3, August 2013.
6. L. Keykhosropur, A. Soroush, and R. Imam, ―3D numerical analyses of geosynthetic encased stone columns, Geotextiles and Geomembranes, vol. 35, pp. 61-68, 2012.
7. H. F. Schweiger and G. N. Pande, ―Numerical analysis of stone column supported foundations, Computers and Geotechnics, vol.2, no. 6, pp. 347-372, 1986.
8. M. D. Babu, S. Nayak, and R. Shivashankar, ―A Critical Review of Construction, Analysis and Behaviour of Stone Columns,‖ Geotechnical and Geological Engineering, vol. 31, no. 1, pp. 1-22, 2013.
9. H. J. Priebe, ―The design of Vibro replacement, Ground Engineering, vol. 28, no. 10, p. 31, 1995.
10. R. D. Barksdale and R. C. Bachus, ―Design and construction of stone columns, National Technical Information Service, vol. 1, 1983.
11. Fathi, E., Mohtasham, R., (2016), "Numerical Analysis of the Reinforced Stone Column by Geosynthetic on Stability of Embankment", Proceedings of the World Congress on Civil, Structural, and Environmental Engineering (CSEE'16), Prague, Czech Republic – IS 2720(Part 29):1975 Methods of test for soils: Part 29 Determination of dry density" May 2010 of soils in place, by the core-cutter method (first revision)
12. IS 2720(Part 7):1980 Methods of test for soils: Part 7 "Determination of water content-" Dec. 2011 dry density relation using light compaction (second revision)
13. IS 2720(Part 13):1986 Methods of test for soils: Part 13 "Direct shear test" Dec. 2011(second revision)
14. IS 2720 (PART 3), Methods of Test for Soils, Determination of Specific Gravity of Soil, 1980.
15. March 30 – 31, 2016, ICGRE, Paper No. ICGRE 112.
16. IS 2720(Part 4):1985 Methods of test for soils: Part 4 "Grain size analysis" May 2010 (second revision)