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Group Performance of Geo-Encased Sand Column

KEYWORDS: Stone Column, Reinforcement, Testing Methodology

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ABSTRACT Number of methods are available to improve the soft clay soils, such as stone columns (Greenwood, 1970; Hughes et al., 1974), vacuum pre-consolidation (Indraratna et al., 2004), soil cement columns (Hashim and Shahidul, 2008), pre-consolidation using pre-fabricated vertical drains (Indraratna and Redana, 1997), lime treatment (Bell, 1996) etc. Among all these methods, the stone column technique is preferred because it gives the advantage of reduced settlements and accelerated consolidation settlements due to reduction in flow path lengths. Stone columns are normally expected to derive their strength and stiffness primarily from the confining stresses provided by the surrounding soil. In order to provide the required lateral column confinement and enhance the bearing capacity in soft soils, the columns may be encased with high stiffness, creep-resistant geosynthetics, resulting in "Geosynthetic Encased Columns (GECs)". In this study, the results of load-settlement behaviour of reinforced sand column placed in clayey soil bed are presented. All tests were conducted in the laboratory at constant temperature and humidity conditions. Effect of various group foundation parameters, such as effect of reinforcement, reinforcement length and reinforcement stiffness is studied in these tests.

1. INTRODUCTION

India has large coastline exceeding 6000 kms. In view of the developments on coastal areas in the recent past, large number of ports and industries are being built. In addition, the availability of land for the development of commercial, housing, industrial and transportation, infrastructure etc. are scarce particularly in urban areas. This necessitated the use of land, which has weak strata, wherein the geotechnical engineers are challenged by presence of different problematic soils with varied engineering characteristics. Many of these areas are covered with thick soft marine clay deposit, with very low shear strength and high compressibility. A number of methods are available to improve the soft clayey soils, such as stone (or granular) columns, vacuum pre-consolidation, soil cement columns, pre-consolidation using pre-fabricated vertical drains , lime treatment etc. Among the various methods for improving in situ ground conditions, stone column are considered one of the most versatile and cost-effective ground improvement techniques.

2. TESTING METHODOLOGY

A total of 15 model tests were conducted as shown in Table 2.1. A schematic view of model stone column foundation is shown in Figure 2.1 and 2.2. The model tests were performed in steel square tank of width 500 mm, 400 mm depth and 10 mm wall thickness. The depth of clay bed was 400 mm.

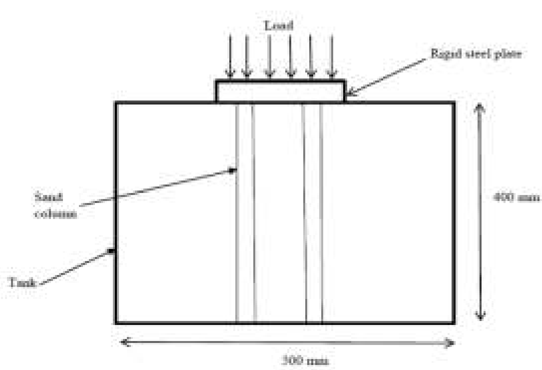

Figure 2. 1: Load tests arrangement

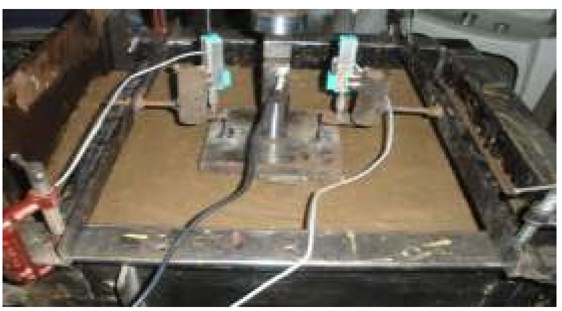

Figure 2. 2: Plan view of a group of stone columns

Test No.	Diameter of column, D (mm)	Area replacement ratio, ARR	Reinforcement length, RL (mm)	Length of column, L (mm)	RL/L	Type
1	-	-	-	-	-	Clay
9	40	19.63	-	400	-	OSC
10	40	19.63	400	400	1	GRSC(Net)
11	40	19.63	200	400	0.50	GRSC(Net)
12	40	19.63	400	400	1	GRSC(Nonwoven
13	40	19.63	200	400	0.50	GRSC(Nonwoven
14	40	19.63	400	400	1	GRSC(Woven)
15	40	19.63	200	400	0.50	GRSC(Woven)

Table 2. : Summary of laboratory model tests

Clay bed was prepared at 36% water content in all the cases. The bulk unit weight at 36% water content was found as 17 kN/m3 having undrained shear strength of 9 kPa. A small group of four stone columns was installed in a square grid pattern by displacement method. All the columns in each group were located within the footing. All the columns were installed at 80 mm centre to centre.

1. RESULTS AND DISCUSSIONS

3.1 Effect of Reinforcement

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Figure 3.1 shows the stress-settlement characteristics of the unimproved clay bed, clay bed improved by OSCs and clay bed improved by GRSCs with net, non-woven and woven geotextile with full reinforcement (i.e. RL/L = 1). The ARR has been taken as 19.63%. From Figure 3.1, it can be observed that load carrying capacity of the OSC does not increase significantly and the use of reinforcement is effective in remarkable increment of the same. Unlike the stress-settlement curve of stone column treated bed, the curve of untreated clay bed is identical to that of plastic clay. Initially, the increase in stress of GRSCs is not rapid. This may be due to initial re-adjustment of the sands. As compared to unimproved clay bed, an improvement of 15% in load carrying capacity is observed when the clay bed is improved with OSC only at 50 mm settlement. . As compared to unimproved clay bed, 45%, 63% and 152% improvement in load-carrying capacity is observed when stone column is reinforced with net, non-woven and woven geotextile respectively at a vertical settlement of 50 mm. For a stress intensity of 25 kPa, as compared to OSC, 17%, 26% and 54% reduction in settlement has been observed with GRSC (Net), GRSC (Non-woven) and GRSC (Woven) respectively; whereas for a stress intensity of 45 kPa, the reduction in settlement for GRSC (Net), GRSC (Non-woven) and GRSC (Woven) is 29%, 39% and 64% respectively. Thus, it can be said that the geogrid reinforcement is more effective for higher stress intensity than for lower stress intensity.

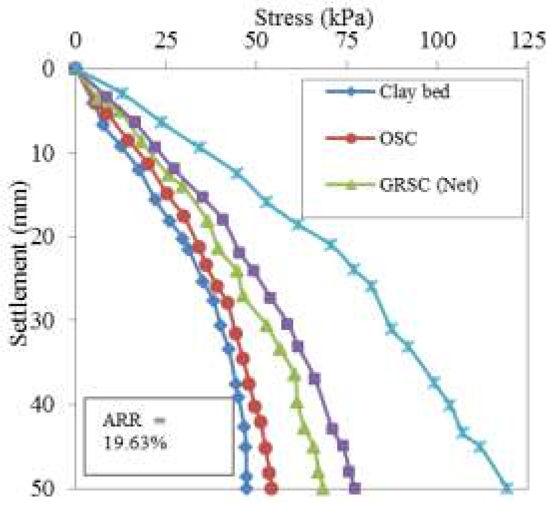

Figure 3. 1 Stress-settlement characteristics of clay bed, OSC and GRSCs

3.2 Effect of Stiffness of Reinforcement

For this study, three different reinforcement materials, Net, Non-woven and woven geotextile are used which having 10% secant modulus of 6 kN/m, 10 kN/m and 23 kN/m respectively. Figure 3.1 shows the stress-settlement response of GRSCs along with clay bed and OSC. From this figure, it can be observed that the stiffness of GRSCs increases with the increase in the secant modulus of the reinforcement material. The increase in the modulus of the reinforcement material results in the increase in its mobilized hoop tension force and lateral confining action, leading to a higher overall stiffness for the stone columns.

3.3 Effect of Length of Reinforcement

Stress-settlement results for fully reinforced and partially reinforced stone column along with the OSC for ARR of 19.63% are presented in Figure 3.2. From Figure 3.2, it is clear that increases in the length of reinforcement improved the performance of the GRSC.

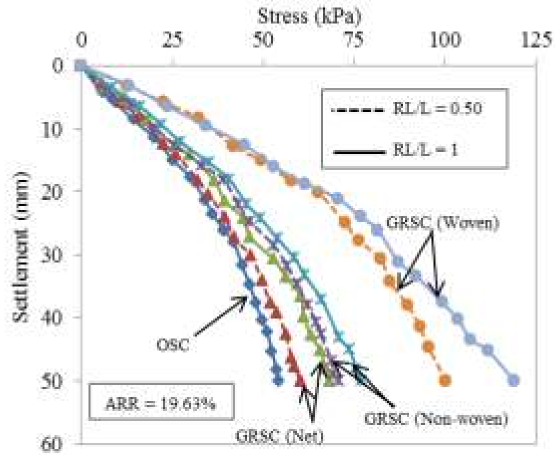

Figure 3.2 Stress-settlement characteristics of GRSCs for different RL/L ratios.

1. CONCLUSION

Based on the results of this investigation, the following conclusions can be drawn.

1) The stress-settlement response of the stone columns group can be improved by reinforcing them with suitable geosynthetic

2) Increasing the modulus of the reinforcement material leads to increase in the overall stiffness of the GRSC group due to generation of higher confining pressure

3) The performance of partial reinforced stone column is close to fully reinforced stone column, which shows that the reinforcement at the top portion of the stone column may be sufficient.

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