American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-08, pp-362-368
www.ajer.org

Research Paper Open Access

Soil Improvement By Using Bamboo Reinforcement

Md Asaduzzaman[1] ; Muhammad Iftiarul Islam[2]

[1] *Student, Dept. of Civil Engg., Rajshahi University of Engineering & Technology, Rajshahi-6204, Bangladesh*

[2] *Student, Dept. of Civil Engg., Rajshahi University of Engineering & Technology, Rajshahi-6204, Bangladesh*

ABSTRACT: *The existing soil at a construction site may not always be totally suitable for supporting structures such as buildings, bridges, highways, and dams. In granular soil deposits, the in situ soil may be very loose and indicate a large elastic settlement. In such case, the soil needs to be improved to increase its unit weight and thus the shear strength and load bearing capacity. Sometimes the top layers of soil are undesirable and must be removed and replaced with better soil on which the structural foundation can be built. For this reason the improvement of load bearing capacity is much more important for making a structural foundation. This paper described a new soil improvement method with a minimum cost solution by using bamboo reinforcement having a length of 12 inch and 0.5 inch in diameter distributed in uniform medium dense soil at different depths (0.75 inch, 1.5 inch and 2.25 inch) below the footings. Three square footings have been used (3x3 inch, 3.5x3.5 inch, 4x4 inch) to carry the above investigation for such purposes. It was found that the initial vertical settlement of footing was highly affected in the early stage of loading in unreinforced soil with compared to bamboo reinforced soil. The failure load value for proposed model in any case of loading increased compared with the un-reinforced soil by increasing the depth of improving below the footing. The load carrying capacity of single layer reinforced soil is increased up to 1.77 times and 2.02 times for multiple reinforced soil system than the load carrying capacity of unreinforced condition of soil. Improvement in load carrying capacity was observed considerable in reinforced soil over the unreinforced soil. For single layer system, load carrying capacity is maximum and settlement is minimum when the reinforcement layer placed at 0.30B. For multilayer system, BCR increases with increasing number of reinforcing layer. One of which is highlighted in the paper, facilitates the improvement of load bearing capacity of soil and spreading the techniques on soft ground.*

Keywords *- Bearing capacity of soil, Square footing, Settlement, Bamboo Reinforcement, Bearing capacity ratio, Depth/breadth ratio or d/B ratio.*

I. INTRODUCTION

The decision of ground improvement is taken for a site area when it needs such treatment methods and also based on the project design performance requirements that will dictate some of design parameters, including the required stability and the allowable deformation (settlements) of related soil under static or dynamic loading. Different types of structures will have different settlement requirement. The well-designed foundations induce stress-strain states in the soil that are neither in the linear elastic range nor in the range usually associated with perfect plasticity. Thus, in order to predict the settlement accurately underneath the foundation rest on soil, analysis that are more realistic than simple elastic analysis are required and a comparison can be made between the settlement for reinforced and unreinforced soil conditions .

Osman (2005) presents the results of a preliminary laboratory investigation on soft clay strengthened by fibers. The system consists of fiber-reinforced sand (the sand mixed with randomly oriented fiber and compacted in layers) between two geo-textiles sheets over fiber-reinforced sand columns inside the soft clay. The results have indicated that the settlement decreases and the bearing capacity increases by using the new system. It shows an effective solution to solve the problem of large settlement of footings over problematic soils such as soft clay.

Al Mosawe et al., (2010) investigated the effect of geo-grid reinforcement installed below square footing rest on sandy soil and subjected to eccentric loading. The results show improvement in the bearing capacity ratio by (22% to 48%) for one and two number of layers respectively without control on the initial settlement that is required for mobilizing reinforcement strength during loading.

Al Mosawe et al., (2011) present the results of improving soft clay soil (i.e. Kaolin) by compacted fly ash. The results show that there is a noticeable improving in the behavior of square footing settlement and bearing capacity ratio (BCR) of (1.3) in average but also without controlling the initial settlement.

It can be concluded from the above studies that reinforcement can increase the bearing capacity and reduce the corresponding settlement of the foundations compared with unreinforced soil. However, it was also found that an initial vertical movement of the reinforcement is still needed to mobilize the reinforcement strength which reflects such matter of the foundation settlements. In the previous studies the initial settlement at small loads still could not be avoided; such requirements is a very important design step that is usually controlled by limiting the expected settlement of footing rest on soil. The study shows new step method to improve soil strength and behavior not only by increasing the bearing capacity and reduce the settlement but also control the initial settlement at initial loads due to the complex interaction of such fibre materials with the soil through the investigated depths.

II. ABBREVIATIONS

2.1 Load bearing capacity:

In Geotechnical Engineering, bearing capacity is the capacity of soil to support the loads applied to the ground. The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil. Ultimate bearing capacity is the theoretical maximum pressure which can be supported without failure; allowable bearing capacity is the ultimate bearing capacity divided by a factor of safety. Sometimes, on soft soil sites, large settlements may occur under loaded foundations without actual shear failure occurring; in such cases, the allowable bearing capacity is based on the maximum allowable settlement

2.2 Settlement:

The downward movement of a structure with respect to its original position is referred to as settlement. The use of reinforcement materials to improve the bearing capacity of soil and to reduce settlement has been proven to be cost-effective solution for foundation design. The reinforcement materials are usually placed horizontally. However, there are cases in which vertical or sloped reinforcement may be used below the footing. The calculation of immediate settlement of footings for different soil types is estimated on the basis of elasticity, provided that the elastic properties of the soil (modulus of elasticity E, and Poisson's ratio υ) are known. These two parameters can be evaluated in the laboratory from soil samples obtained during site investigation processes for cohesive soils. However, for granular soils, it is much more difficult, if not impossible in most cases. The in-situ testing for granular soils may not accurately give these soil properties which are needed for the calculation of settlement.

III. EXPERIMENTAL PROGRAM

The soil sample was collected from Godagari, Rajshahi, Bangladesh. After collecting the soil sample, sieving was done by different sieve. Grain size curve was plotted by Hydrometer analysis, soil constituents also determined from this. The soil is classified into Sandy loam from textural classification. Then Atterberg limits were determined from Casagrande apparatus. The Atterberg limits are- Liquid Limit (LL)- 41.3, Plastic Limit (PL)- 23.7, Plasticity Index (PI)- 17.6;

Oven dried weight was used for determining dry density, moisture content, Specific Gravity. The soil properties are- Dry density- 104.7 pound per cubic feet, Moist density- 121 pound per cubic feet, Specific Gravity- 2.63, Moisture content of the soil sample- 16%, Void ratio- 0.59, Porosity- 0.37

After determining the soil properties, the soil sample was placed for CBR test. Bamboo reinforcement having 0.5 inch diameter and 12 inch long was placed into the soil at different depth. The bamboos were horizontally spaced at 1.75 inch interval to each. Density/degree of compaction was ensured by Standard Proctor Test. Every specimen was compacted in 3 layers by a hammer that delivers 25 blow to each. The hammer weights 5.5 lb and has a drop of 12 inch. Then the model type footing was placed over it and was taken into the CBR machine. The sample model was accustomed to load in the CBR machine and corresponding settlement data was recorded instantly. Using this procedure, the experiment was executed on different layer systems of bamboo reinforcement in different depth (i.e. 0.75 inch, 1.5 inch, 2.25 inch) and also changed of the footing dimension (i.e. 3x3inch, 3.5x3.5 inch, 4x4inch). The orientation of the multi-layer system was parallel-perpendicular-parallel. The bearing capacity and settlement of the footing resting on soil depend on the properties of soil such as the relative density, size, shape and embedment depth of footing (Lambe and Whitman,1979).The results obtained from such model tests are usually hindered by limitations associated with size and boundary effects. Consequently, it is important to keep such limitations in mind while designing such small model tests.

Fig. 1 Top view of placement of reinforcement and sample preparation

Fig. 2 General arrangement and loading the sample

IV. RESULT AND DISCUSSION

This experiment was performed for different dimensions of footing with different layer system of bamboo reinforcement. The layer systems were- single layer system, two layer system, three layer system of bamboo reinforcement. And the footing sizes were- 3 inch x 3 inch, 3.5 inch x 3.5 inch, 4 inch x 4 inch.

Table 1 Table for showing the data were tested in the experiment.

Footing Size (inch x inch)	No. Of reinforcing layers, N	Depth of top reinforcing layer below footing, d (inch)	Depth of layers below the footing, d (inch)
3x3 3.5x3.5 4x4	1	0.75, 1.5, 2.25	-
	2	0.75	0.75, 2.0
	3	0.75	0.75, 2.0, 3.0

The following parameters were considered in this study:

a. Improvement for the bearing capacity of soil related to footing size.
b. Experimental and calculated settlement comparison.
c. Experimental and calculated comparison in bearing capacity ratio (BCR) with d/B ratio.

For the footing 3 x 3 inch, the settlement versus stress (load/area) graph are given below-

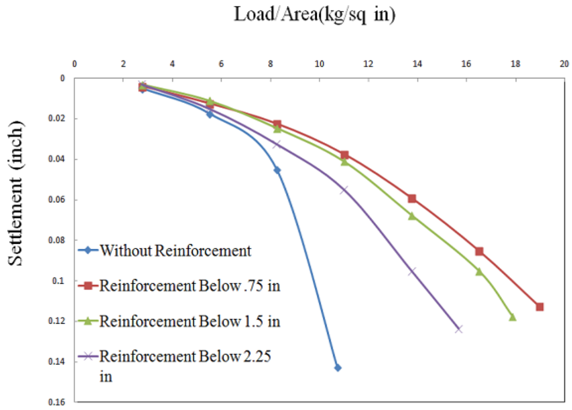

Fig. 3 Settlement versus stress (load/area) graph for 3inch x3inch footing

For the footing 3.5 x 3.5 inch, the settlement versus stress (load/area) graph are given below-

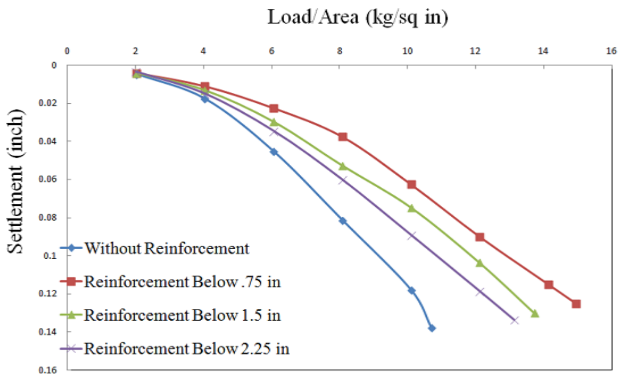

Fig. 4 Settlement versus stress (load/area) graph for 3.5 inch x 3.5 inch footing

For the footing 4 x 4 inch, the settlement versus stress (load/area) graph are given below-

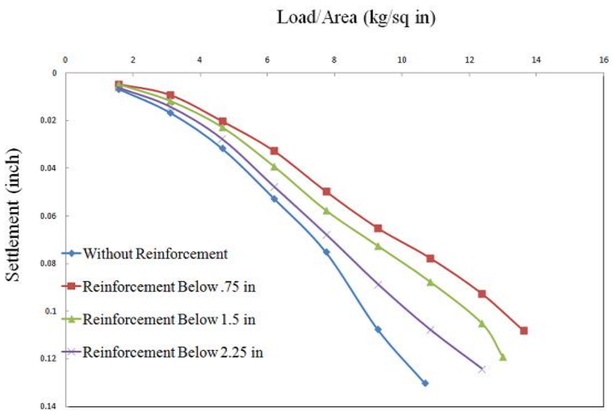

Fig. 5 Settlement versus stress (load/area) graph for 4 inch x 4 inch footing

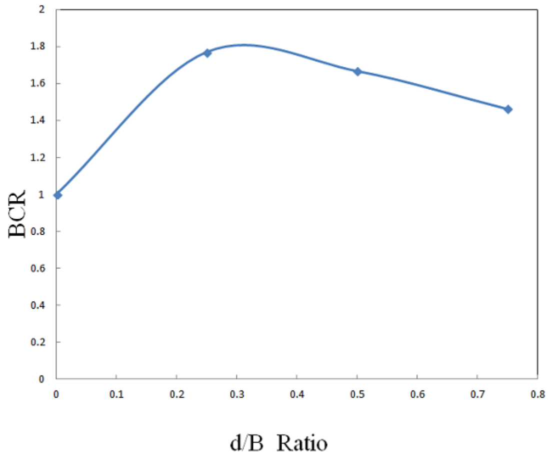

Fig. 6 Variation of Bearing Capacity Ratio (BCR) with respect to d/B Ratio for single layer.

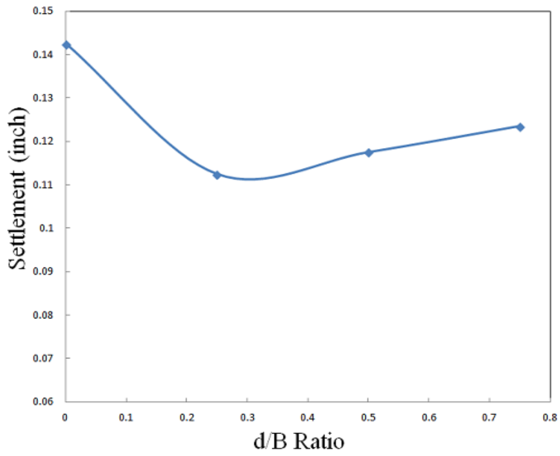

Fig. 7 Variation of Settlement (inch) with respect to d/B Ratio For single layer.

Multiple Layer Reinforcement System:

For the footing 3 x 3 inch

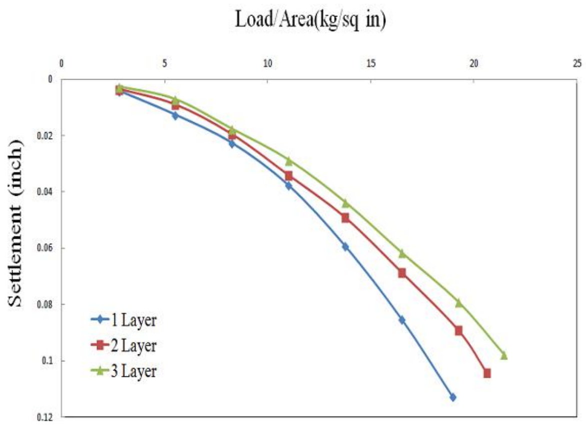

Fig. 8 Settlement versus stress (load/area) graph for 3 inch x 3 inch footing

For the footing 3.5 x 3.5 inch:

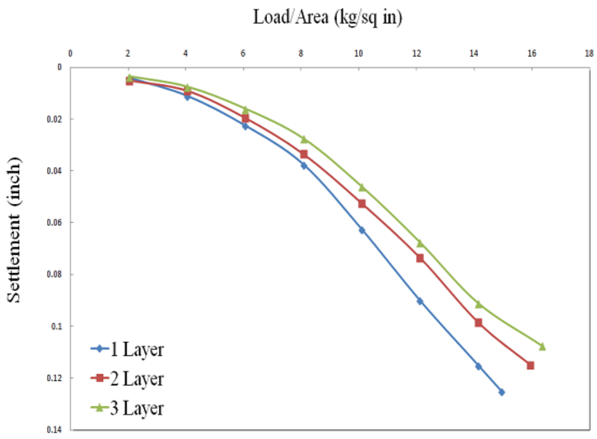

Fig. 9 Settlement versus stress (load/area) graph for 3.5 inch x 3.5 inch footing

For the footing 4 x 4 inch:

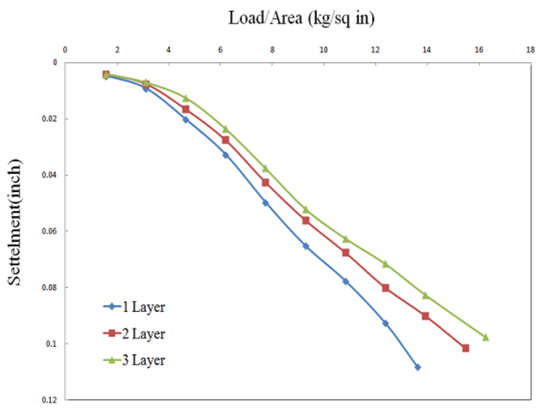

Fig. 10 Settlement versus stress (load/area) graph for 4 inch x 4 inch footing

Bearing Capacity Ratio (BCR) increases with the increase of number of reinforcing layers.

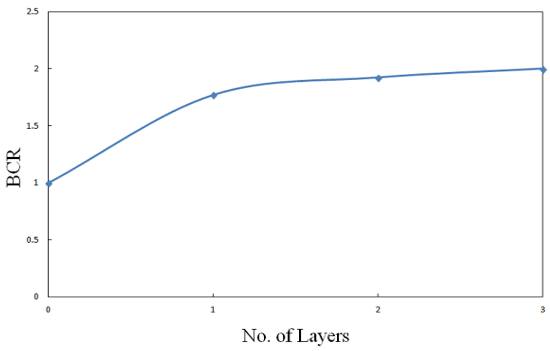

Fig.11 Variation of Bearing Capacity Ratio (BCR) with respect to number of reinforcing layer.

Settlement decreases with the increment of number of layers

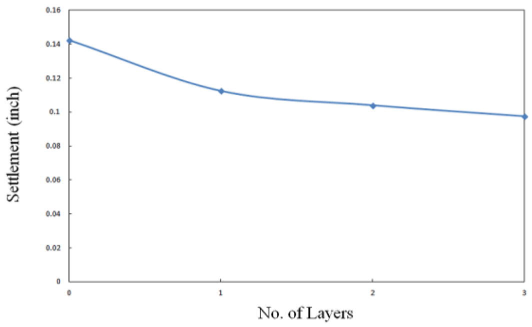

Fig. 12 Variation of Settlement (inch) with respect to number of layers

The bearing capacity of soil was improved by using bamboo reinforcement of single or multiple layers in 3 x 3 inch, 3.5 x 3.5 inch, 4 x4 inch footings. The load/area-settlement relationships are shown in Figures (3) to (5) for single layer of bamboo reinforcement in different depth (i.e. 0.75 inch, 1.5 inch, 2.25 inch). For single layer reinforcement, settlement was more in using no reinforcement & it was decreased with decrease of depth of reinforcement layer. It was found that with the increase of depth/breadth (d/B) ratio, the Bearing Capacity Ratio (BCR) increased but after certain value of d/B ratio, the BCR value decreased. Again, settlement decreased with the increment of d/B ratio but after certain value of d/B ratio it increased. The high bearing capacity ratio (BCR) & low settlement was found in 0.30B depth as shown in the figures (6) & (7) for footing 3 x 3 inch.

For getting more bearing capacity, the layer of bamboo reinforcement was increased. Reinforcement was placed in 1, 2, 3 layers in square footing respectively. The variation of load/area-settlement for multiple layers reinforcement is shown in figures (8) to (10). In this diagram, it is found that the increasing of no. of layers decreases the settlement & thus it increases the soil bearing capacity. Figure (11) & (12) shows that the increase of number of bamboo reinforcement layers, increases the load bearing capacity and decreases settlement of soil.

V. Conclusion

1. The load bearing capacity of soil increases when the bamboo reinforcement placed within the depth of failure envelope.
2. The load bearing capacity is increased up to 1.77 times for single layer reinforced soil and 2.02 times for multiple layer reinforced soil system than the load bearing capacity of unreinforced condition of soil.
3. Improvement in load bearing capacity is observed considerable in reinforced soil over the unreinforced soil. For single layer system, load bearing capacity is maximum and settlement is minimum when the reinforcement layer placed at 0.30B.
4. For multilayer system, BCR increases with increasing number of reinforcing layer (N). The BCR is maximum for N=3 but the percentage increase in BCR for N=3 over N=2 is very small (4%).
5. In multi-layer reinforcing system, settlement is considerably decreases with the increasing number of reinforcing layer.

REFERENCES

[1] Al Mosawe M. J., Al Albusoda B. S., and Yaseen A. S. (2011). "Bearing Capacity of Shallow Footing on Soft ClayImproved by Compacted Fly Ash" Journal of Engineering, No.6,Vol. 17, pp (1473-1482).
[2] Al Mosawe M. J., Al Saidi A. A., and Jawad F. W. (2010). "Bearing Capacity of Square Footing on Geogrid Reinforced Loose Sand to Resist Eccentric Load", Journal of Engineering, No.2, Vol. 16, pp (4990-4999).
[3] Bassat, R. H. and Last, N. C. (1978). "Reinforced Earth below Footing and Embankments", Symposium Proc. conf. on Earth Reinforcement, ASCE, Pittsburgh, pp(202-231).
[4] Bieganousky, W. A. and Marcuson, W. F., (1976). " Uniform Placement of Sand" J. of Geot. Eng.Div., ASCE, Vol. (102), GT3. pp(229-235).
[5] Binquet and Lee, K. L., (1975a). " Bearing Capacity Tests on Reinforced Earth Slabs". J. of Geot. Eng.Div., ASCE, Vol. (101), GT12. pp(1241-1255).
[6] Das, B. M. (1988) "Shallow Foundation on Sand Underlain by Soft Clay with Geotextile Interface"Geosynthetics for Soil Improvement conf. pp(112-126).
[7] Fragaszy, R. J. and Lawton, E., (1984). "Bearing Capacity of Reinforced Sand Subgrade". J. of Geot. Eng.Div., ASCE, Vol. (110), GT10. pp(1500-1507).
[8] Jones, C. J. F. P. (1985). "Earth Reinforcement and Soil Structures". Butter worth advance series in Geot Eng .
[9] Khan, S. A. (2005), "Stabilization of Soil Using Bamboo Industry Waste", 32:18-19 July, Coimbra, Portugal, pp (357-362).
[10] Lambe, T. W., and Whitman, R. U. (1979). "Soil Mechanics"; Published by John Wiley and Sons. Inc.
[11] Mekkiyah, H. M., and Alansari, O. M. (2004). " Settlement Reduction Underneath Surface Circular Footings Rest on Reinforced Sand". Int. Conference on Geot. Eng., Oct., 3-6, Sharjah-UAE,pp(327-333).
[12] Milligan, G. W. E., and J. P. Love (1984) "Model testing of geogrids under and aggregate layer in soft ground" Proceedings, Symposium on polymer Grid Reinforcement in Civil Engineering, ICI, London, England, 4.2.1-4.2.11
[13] Milovic, D. (1977) "Bearing Capacity Tests on Reinforced Sand", Proc. of the 9th International conf. on Soil Mechanics and Foundation Engineering, Tokyo, Japan, 1, pp(651-654).
[14] Osman, E. A. M. (2005), "Reinforced Earth Mat Foundation over Fiber-Reinforced Sand Columns inside soft Clay", J. of Nepal Geological Society, Vol. 32, pp(16-24).