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The Effects of Reinforced and Unreinforced Sand Bed over Ground Improved With Stone Columns

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Abstract— Soft clay soils there are in many coastal areas. Various techniques are used to improve these soils. Among existing techniques, stone columns are known as quick and inexpensive method. Stone columns in soft soil improve bearing capacity because they are stiffer than the material which they replace, and compacted stone columns produce shearing resistances which provide vertical support for overlying structures or embankments. Stone columns accelerate the consolidation in the native surrounding soil and improve the load settlement characteristics of foundation. Due to the poor performance of columns in very soft soils such as peat, various methods have been developed to increase the efficiency of the columns such as vertical encased, horizontal reinforced and construction of reinforced and unreinforced sand bed over the stone columns. This article presents a review on behaviour of reinforced and unreinforced sand bed over the stone column improved ground and effectiveness of this technique on the bearing capacity, settlement and bulging of stone column.
Keywords— Stone Columns, Sand Bed, Geogerid, Stress Concentration

I. INTRODUCTION

The improvement of compressible soils by stone columns became very popular because of substantial advantages like the increase in bearing capacity, the reduction in settlement accompanied by the acceleration of consolidation in case of clayed soils, and the prevention of liquefaction potential in case very loose saturated sands [1].

In this method, when the vibrator poker penetrate the soil, the excavated borhole, backfilled in successive stages with coarse aggregate, which is compacted by re-lowering the poker. This process results in stone columns which are tightly inter-locked with the surrounding soil [2]. Stone columns can easily be constructed up to a diameter of 1.5 meter and typically replace 10–35% of the in situ soil [3]. For some structures such as liquid storage tanks, abutments, embankments, and factories rested on compressible soils that can tolerate some settlement, stone columns are an economical improvement method.

So far, several methods have been proposed to increase the efficiency of stone columns in ground improvement such as vertical encasement and horizontal reinforcement of the stone column, stone column with vertical circumferential nails and construction of reinforced and unreinforced sand bed over the stone columns. In this paper a review is carried out on behaviour of reinforced and unreinforced sand bed over the stone column improved ground and effectiveness of this technique on the bearing capacity, settlement and bulging of stone column were evaluated.

II. REINFORCED AND UNREINFORCED SAND BED OVER STONE COLUMNS

For drainage purposes, as well as distribution of the stresses coming from superstructures a granular layer of sand or gravel, with the thickness of 30 cm or more, is usually placed over the top of the stone columns [4]. Bulging and subsequent failure of granular pile occur near top of the granular pile due to high stress concentration in this region. These stresses are significantly influenced by the presence of granular bed [5].

Shahu et al. [5] developed a theoretical approach to analyze the behavior of soft ground reinforced by granular piles with granular mat on top, under a rigid foundation. The granular mat is assumed to be rigid and smooth. They concluded that placement of the granular bed on top of granular pile reinforced ground, leads to a desirable reduction in stress concentration ratio near the top of the pile and to reductions in normalized displacements, percentage load carried by granular pile at top and interface shear stresses.

Ambily and Gandhi [6] describes results of numerical analysis on effect of sand pad thickness on load sharing between column and soil (stress concentration ratio) (SCR) for both flexible and rigid loading condition in a unit cell. They concluded that in the case of rigid load, SCR decrease with increase in the t_{sand}/d (t_{sand} and d are sand thickness and stone column diameter, respectively) up to a value of 0.75 beyond wich the effect is negligible. Whereas in the case of flaxible load, SCR increasee with increase in the t_{sand}/d up to a value of 0.8 to 1.25 beyond wich the effect is negligible (Fig. 1).

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They observed that in rigid loading stress concentration ratio decrease slowly with increase in s/d ratio (s is spacing between stone columns) up to a s/d of 3 beyond wich the reduction is negligible and in the case of flexible loading a sharp decrease in stress concentration ratio occurs as s/d increases from 1.5 to 2 and on further increase in s/d, stress concentration ratio decreases slowly up to an s/d of 3 beyond wich it remains constant (Fig. 2).

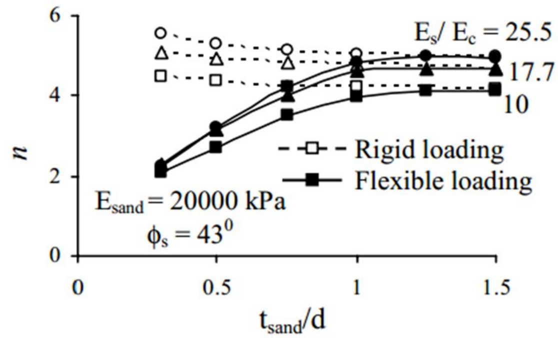

Fig. 1 Stress concentration ratio versus t_{sand}/d [6]

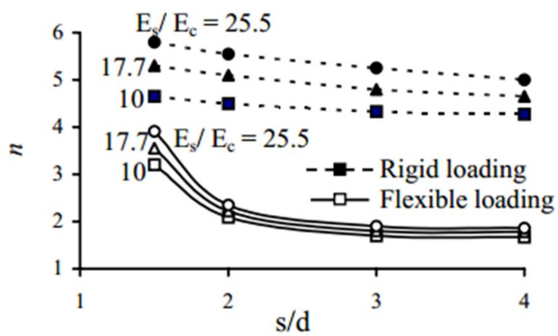

Fig. 2 Stress concentration ratio versus s/d [6]

Nassaji and Asakereh [7] carried out numerical simulations using Flac3D on granular bed-stone column improved ground and investigated the effects of granular bed on bearing capacity, settlement and bulging. Their results indicated that placement of the granular bed over the stone column improved ground significantly increases the bearing capacity and decreases the settlement of the ground and these effects increases with increasing thickness of the granular layer. The effects of different thickness of granular bed (t) on the BCR (bearing capacity ratio) and SIF (settlement improvement factor) are shown in Fig. 3, where D_f is footing diameter.
Lateral bulging of the stone column at a pressure load of 100 kPA is shown in Fig. 4, where D_f, D_c and ΔD_c are footing diameter, initial diameter of the column and variations of the column diameter due to loading, respectively. They observed that placement of the granular bed with thickness of $0.15D_f$, reduce the bulging of the column about 24%. Further reductions in bulging was observed by increasing thickness of the granular bed.

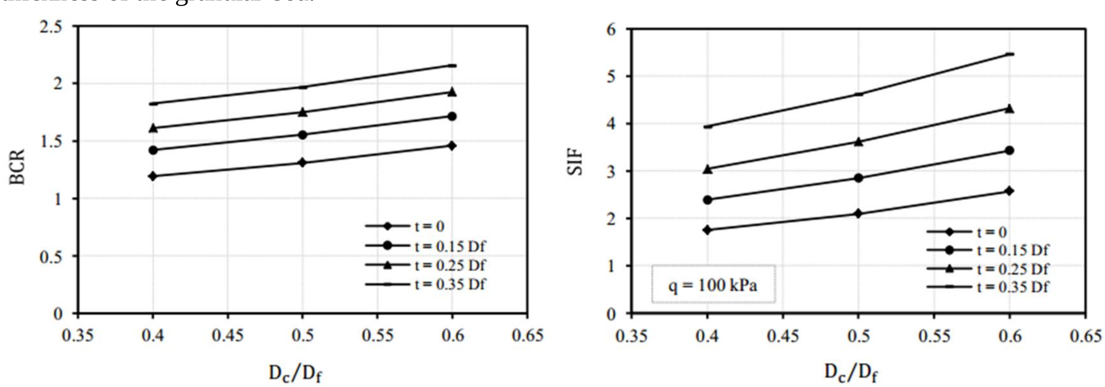

Fig. 3 Effect of granular bed thickness on BCR and SIF [7]

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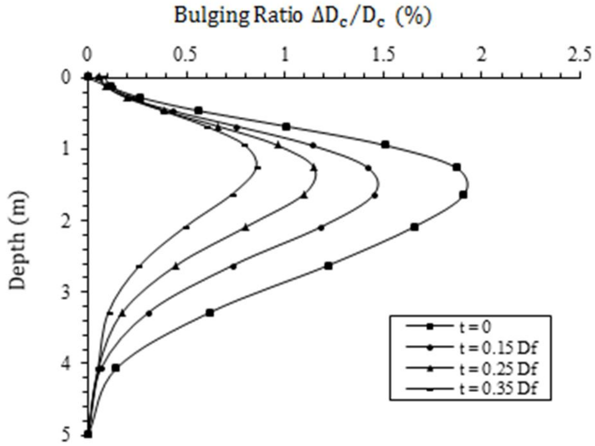

Fig. 4 Bulging ratio versus the Depth for different thickness of granular bed at pressure of 100 kPa [7]

According to Fig. 5, they stated that a granular layer acts as a stress distributor, and transfers the applied stresses to depth of the column, where more support takes place from the surrounding soil. This causes that lower bulging occurs in the column.

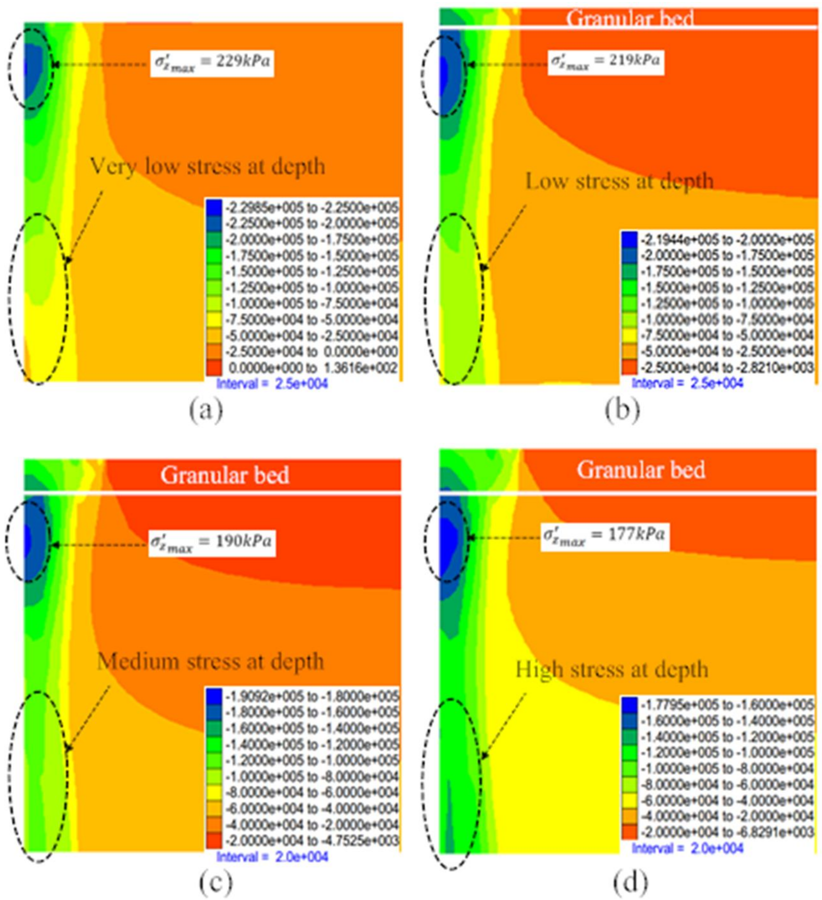

Fig. 5 Effective stress contours for different thickness of granular bed at pressure of 100 kPa: a) t = 0, b) t = 0.15 D_f, c) t = 0.25 D_f, d) t = 0.35 D_f [7]

Deb [8] developed a mechanical model for predicting the behaviour of stone column-improved soft ground with granular bed placed over the stone columns. It has been observed that the presence of granular bed on top of stone column-reinforced ground reduces the stress concentration near top of the columns. The granular bed can be further reinforced with geogrid to enhance the load-carrying capacity and reduce the settlement of the stone column-improved soft clay.

Deb et al. [9] reported results of a series of laboratory model tests on unreinforced and geogrid-reinforced sand bed resting on stone column-improved soft clay. Fig. 6 shows the load-settlement characteristics of the unimproved clay bed, clay bed improved by stone column alone and clay bed improved by stone column along with 30 mm thick unreinforced and geogrid-reinforced sand bed.

They concluded that the placement of sand bed increases the load-carrying capacity and decreases the settlement of the stone column improved soil and the inclusion of geogrid as reinforcing element in the sand bed significantly improves the load-carrying capacity and reduces the settlement of the soil. They observed 69%, 141% and 233% improvement in loadcarrying capacity as compared to unimproved soft clay (at settlement equal to 20% of the footing diameter), when soft clay is improved by stone column alone, by placing of unreinforced and geogrid-reinforced sand bed of optimum thickness over stone column, respectively.

They observed decrease in bulge diameter and increase in depth of bulge due to placement of sand bed over stone column-improved soft clay. Also further decrease in maximum bulge diameter and increase in depth of observed due to application of geogrid. The maximum bulge was at a depth of 1.2, 2.2 and 2.9 times the diameter of stone column in case of soil improved by stone column alone and by placing of unreinforced and geogridreinforced sand bed over stone column, respectively (Fig. 7).

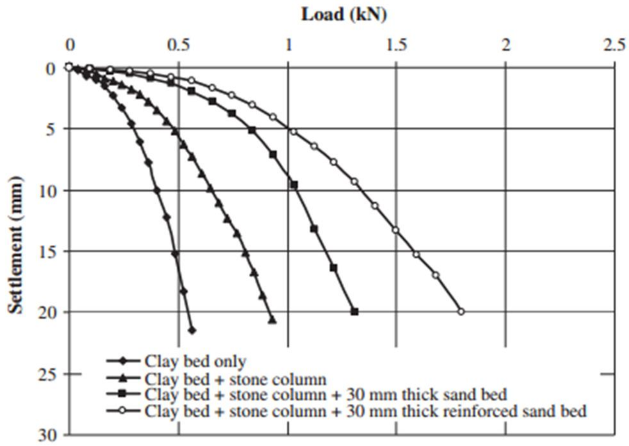

Fig. 6 Load-settlement characteristics of various reinforced conditions [9]

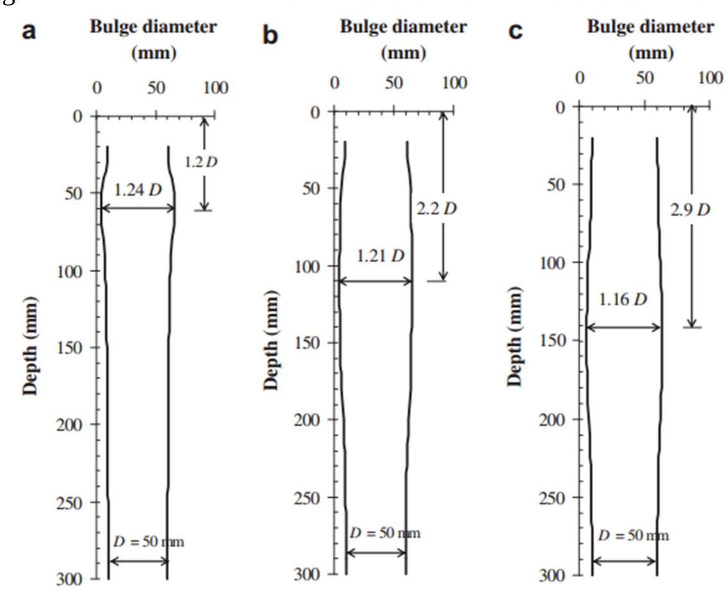

Fig. 7 Bulging of the stone column when soft clay has been improved with (a) stone column alone (b) stone column with 30 mm unreinforced sand bed (c) stone column with 30 mm geogrid-reinforced sand bed [9]

III. CONCLUSIONS

In this paper a review on the effects of reinforced and unreinforced sand bed over ground improved with stone columns is done. Based on performed studies, the following conclusions are drawn:

A granular layer acts as a stress distributor, and transfers the applied stresses to depth of the column, where more support takes place from the surrounding soil.

Placement of sand bed increases the bearing capacity and decreases the settlement of the stone column improved soil and further improvement is achieved with inclusion of reinforcement layers such as geogrid in the sand bed.

Decrease in bulge diameter and increase in depth of bulge occurs due to placement of sand bed over stone column-improved soft clay. Further decrease in maximum bulge diameter and increase in depth of can be achieved due to application of geogrid.

REFERENCES

[1] V. Six, H. Mroueh, I. Shahrour, and M. Bouassida, "Numerical analysis of elastoplastic behavior of stone column foundation," Geotechnical and Geological Engineering, vol. 30, pp. 813-825, 2012.

[2] W. Sondermann and W. Wehr, "Deep vibro techniques," Ground Improvement, 2nd edn (MOSELEY MP and KIRSCH K.(eds)). Spon Press, Abingdon, pp. 57-92, 2004.

[3] M. Killeen, "Numerical modelling of small groups of stone columns " PHD, National University of Ireland, Galway, 2013.

[4] J. K. Mitchell, "Soil improvement—state of the art report," Proc., 10th Int. Conf. on Soil Mechanics and Foundation Engineering, vol. 4, pp. 509–565, 1981.

[5] J. Shahu, M. Madhav, and S. Hayashi, "Analysis of soft ground-granular pile-granular mat system," Computers and Geotechnics, vol. 27, pp. 45-62, 2000.

[6] A. Ambily and S. Ganghi, "Effect of sand pad thickness on load sharing in stone column," in Proceedings Indian geotechnical conference, Chennai, 2006, pp. 555-556.

[7] F. Nassaji and A. Asakereh, "Effect of Granular Bed on Behaviour of Stone Column Improved Ground," International Journal of Science and Engineering Investigations, vol. 2, pp. 67-71, 2013.

[8] K. Deb, "Modeling of granular bed-stone column-improved soft soil," International journal for numerical and analytical methods in geomechanics, vol. 32, pp. 1267-1288, 2008.

[9] K. Deb, N. K. Samadhiya, and J. B. Namdeo, "Laboratory model studies on unreinforced and geogrid-reinforced sand bed over stone column-improved soft clay," Geotextiles and Geomembranes, vol. 29, pp. 190-196, 2011.