Improvement of Soft Marine Clay with Laterally Reinforced Silica-Manganese Slag Stone Column

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Abstract

Among all the techniques available for ground improvement, stone columns are the most preferred elements used for supporting a wide variety of flexible structures such as road, railway embankments, and oil storage tanks. In this study, several laboratory tests have been conducted to improve the soft marine clay with end bearing stone columns by using Silica-Manganese slag as stone column material. Further, these stone columns were reinforced with circular geotextile discs by placing them laterally within the column. The improvement in load carrying capacity was studied and compared to the clay bed and unreinforced i.e. plain stone column. Circular geotextile discs of two different spacings (D and D/2, where "D" is the diameter of the stone column) with varied reinforcement depths, such as D, 2D, 3D and 4D, were tried. It was found that the soil reinforced with a spacing of D/2 to the embedment length of 3D shows better performance than a spacing of D. It was also observed that the bulging diameter was reduced by incorporation of the geotextile reinforcement and found below the reinforcement.

Keywords: Stone column, Marine clay, Silica-Manganese slag, Geotextile discs

References

[1] D. A. Greenwood, "Mechanical improvement of soils below ground surface," in Conference on Ground Engineering, Institution of Civil Engineers, 1970, pp. 11-22.

[2] J. M. O. Hugher and N. J. Withers, "Reinforcing of soft cohesive soils with stone columns," Ground engineering, vol. 7, pp. 42-49, 1974.

[3] M. R. Madhav and P. P. Vitkar, "Strip footing on weak clay stabilized with a granular trench or pile," Canadian Geotechnical Journal, vol. 15, pp. 605-609, 1978.

[4] H. Aboshi, E. Ichimoto, K. Harada, and M. Emoki, "The compozer, a method to improve characteristics of soft clays by inclusion of large diameter sand columns," in International conference on soil reinforcement, Paris, 1979, pp. 211-216.

[5] J. M. O. Hughes, N. J. Withers, and D. A. Greenwood, "A field trial of the reinforcing effect of a stone column in soil," Geotechnique, vol. 25, pp. 31-44, 1975.

[6] J. M. McKenna, W. A. Eyre, and D. R. Wolstenholme, "Performance of an embankment supported by stone columns in soft ground," Geotechnique, vol. 25, pp. 51-59, 1975.

[7] T. Ayadat, A. Hanna, and M. Etezad, "Failure process of stone columns in collapsible soils," International Journal of Engineering, Transactions B: Applications, vol. 21, pp. 135-142, 2008.

[8] S. Murugesan and K. Rajagopal, "Experimental and numerical investigations on the behaviour of geosynthetic encased stone columns," in Indian Geotechnical Conference, 2009, pp. 480-484.

[9] S. Murugesan and K. Rajagopal, "Studies on the behavior of single and group of geosynthetic encased stone columns," Journal of Geotechnical and Geoenvironmental Engineering, vol. 136, pp. 129-139, 2010.

[10] J. Gniel and A. Bouazza, "Improvement of soft soils using geogrid encased stone columns," Geotextiles and Geomembranes, vol. 27, pp. 167-175, 2009.

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[11] N. Samadhiya, P. Maheshwari, A. Zsaki, P. Basu, and A. Kundu, "Strengthening of clay by geogrid reinforced granular pile," International Journal of Geotechnical Engineering, vol. 3, pp. 377-386, 2009.
[12] M. Hasan and N. K. Samadhiya, "Soft soils improvement by granular piles reinforced with horizontal geogrid strips," International Journal of Geotechnical Engineering, vol. 12, pp. 101-108, 2018.
[13] S. N. Malarvizhi and K. Ilamparuthi, "Load versus settlement of clay bed stabilized with stone and reinforced stone columns," in Proceedings of GeoAsia–2004, Seoul, Korea, 2004, pp. 322-329.
[14] N. Hataf and N. Nabipour, "Experimental investigation on bearing capacity of geosynthetic encapsulated stone columns," in 18th International Conference *on Soil Mechanics and Geotechnical Engineering*, Paris, 2013, pp. 2493-2496.
[15] S. N. Malarvizhi and K. Ilamparuthi, "Comparative study on the behavior of encased stone column and conventional stone column," Soils and Foundations, vol. 47, pp. 873-885, 2007.
[16] M. Y. Fattah, K. T. Shlash, and M. J. M. Al-Waily, "Stress concentration ratio of model stone columns in soft clays," Geotechnical Testing Journal, vol. 34, pp. 50-60, 2011.
[17] M. Y. Fattah, H. A. Mohammed, and H. A. Hassan, "Load transfer and arching analysis in reinforced embankment," Proceedings of the Institution of Civil Engineers-Structures and Buildings, vol. 169, pp. 797-808, 2016.
[18] M. R. D. Babu, R. Shivashankar, S. Nayak, and J. A. Majeed, "Load settlement behavior of stone columns with circumferential nails," in Indian Geotechnical Conference, India, 2010, pp. 579-582.
[19] P. Basu, N. K. Samadhiya, and S. S. De Dalal, "An experimental study on random fiber mixed granular pile," International Journal of Geotechnical Engineering, vol. 12, pp. 1-12, 2018.
[20] K. Ali, J. T. Shahu, and K. G. Sharma, "An experimental study of stone columns in soft soils," in Indian Geotechnical Conference, India, 2011, pp. 375-378.
[21] M. Hasan and N. K. Samadhiya, "Experimental and numerical analysis of geosynthetic-reinforced floating granular piles in soft clays," International Journal of Geosynthetics and Ground Engineering, vol. 2, pp. 1-13, 2016.
[22] P. Mohanty and M. Samanta, "Experimental and numerical studies on response of the stone column in layered soil," International Journal of Geosynthetics and Ground Engineering, vol. 1, pp. 1-14, 2015.
[23] M. Y. Fattah, B. S. Zabar, and H. A. Hassan, "Experimental analysis of embankment on ordinary and encased stone columns," International Journal of Geomechanics, vol. 16, pp. 1-13, 2016.
[24] A. P. Ambily and S. R. Gandhi, "Behavior of stone columns based on experimental and FEM analysis," Journal of geotechnical and geoenvironmental engineering, vol. 133, pp. 405-415, 2007.
[25] M. R. Malekpoor and G. R. Poorebrahim, "Behavior of compacted lime-soil columns," International Journal of Engineering-Transactions B: Applications, vol. 27, pp. 315-324, 2014.
[26] D. A. Greenwood and K. Kirsch, "Specialist ground treatment by vibratory and dynamic methods," in Piling and ground treatment, 1984, pp. 17-45.
[27] G. G. Meyerhof and V. V. R. N. Sastry, "Bearing capacity of piles in layered soils," Canadian geotechnical journal, vol. 15, pp. 171-182, 1978.
[28] J. A. Black, V. Sivakumar, M. R. Madhav, and G. A. Hamill, "Reinforced stone columns in weak deposits: laboratory model study," Journal of Geotechnical and Geoenvironmental Engineering, vol. 133, pp. 1154-1161, 2007.
[29] Indian standard code of practice for design and construction for ground improvement - guidelines. Part 1: Stone columns, IS 15284 (Part-1), 2003.