Analysis of Ground Improvement by Stone Column Method

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***Abstract*— The social, economic, cultural and industrial growth of any country depends heavily on its transportation system. The only mode which could give maximum service to one and all is transportation by highways and railways. As a result of development of infrastructures like buildings, highways, railways, and other structures in recent past years has resulted in scarcity of good quality of land for construction projects. Aim of this project is, study the various construction method adopting for improve the soil or ground. Every method had it's own pros and cons, which will help to decide the most suitable method for problematic soil to improve it's capacity. So it can be available to carry each type of civil engineering structures. Selection of method based on situation and required results, here are taken case study of Coastal road project. Project duration and economy also main factor affecting on selection.**

Keyword: Stone Column, Soil, Ground Improvement, cost effective

1. INTRODUCTION

In a construction project, there are numerous foundation problems that are encountered during the execution phase. Soil in its natural form, at a construction site, is not always suitable to completely bear heavy structural loads. For such situations, the soil needs to be improved to enhance its bearing capacity and decrease the expected settlement. It is due to rapid growth of population, fast urbanization and more development of infrastructures like buildings, highways, railways and other structures in recent past years has resulted in reduction of availability of good quality of land. Therefore, engineers have no choice left except to use soft and weak soils around by improving their strength by means of suit-able modern ground improvement techniques for construction activities. Therefore, the engineers are bound to adopt inferior and weak soil for construction. In present scenario the role of ground improvement techniques has become an important and crucial task for various construction projects. By ground improvement techniques the strength of the soil increases, its compressibility reduces and the performance under applied loading enhances. The expansive and collapsible soils are challenges to engineers due to their peculiar behavior of high swelling and shrinkage action.

2. STATE OF DEVELOPMENT

Galande Shubhada et. al. (2022) In order to enhance infrastructure projects, large civil engineering projects are executed in India. Due to space constraints and time limits infrastructure facilities have to often build on site where the soil conditions are not ideal. This is where the geotechnical engineer plays a critical role in improving the soil conditions. The method of ground improvement is adopted depends upon the nature of strata and the purpose of improvement. Under different improvement techniques, ground improvement using stone columns offers a proven and economical solution. In this project, we are going to make a stone column and take test on the sample. The soil has been classified by conducting test such as sieve test, plastic limit test, liquid limit test, standard proctor test, unconfined test with different composition. We have used fly ash, jute, fiber glass chicken mesh, stone aggregate and soil to know which composition gives more strength to the soil.

Isabela Dellalibera Piccinini et. al. (2015) The research has four main goals to investigate and understand, for the four existing methods individually, how each one of the input parameters considered in the equations for the Settlement Improvement Factor calculation affect the output results. Search for a way to simplify the representation of the equations used for the Settlement Improvement Factor calculation, in order to facilitate their understanding and application in practice, using dimensionless input parameters and pointing out which

these parameters must be calibrated with a high precision for having a great influence on the final results. Compare the results obtained for the four different methods analyzed to identify conditions that may converge the results of two different methods in order to try to point out one of them as a general method to be used with a good level of reliability and that is also in favor of safety. Study real and/or fictional cases in order to compare de results obtained for the studied methods.

Istuti Singh et. al. (2019) Stone columns repeatedly used for stabilization of soft soils. For the support of different structures, use of stone columns is increasing day by day. Stone columns are used for the improvement of settlement and bearing capacity of soft soils in reasonable fare and friendly towards the environment. In present paper, a review to analyse the behavior of stone columns used in different types of constructions such as oil storage tanks, embankments, buildings etc. The consequence of without encased and encased stone columns on several types of construction is studied. The effect of various diameters with various depths in ground also reviewed. For the encasement different types of geo-synthetics are used for improvement of the results. For the prediction of the settlement of foundations reinforced with stone column number of numerical and physical approaches are done. This paper deals with several theories exist from past to present which helps in understanding the enhancements by stone columns in boosting soft soils. In development of geotechnical properties physical modelling has an important role.

Karun Mani et. al. (2013) Ground improvement is an important requirement in today's construction industry as land reclamation is becoming increasingly popular. The stone column technique is a very efficient method of improving the strength parameters of soil like bearing capacity and reducing consolidation settlement. It offers a much economical and sustainable alternative to piling and deep foundation solutions. Ground improvement when implemented through stone column technique aids in a much stable solution to construction in weak cohesive soils. The paper is an attempt to discuss in detail about this technique to improve soil stability, including it's salient features, design parameters, major functions and drawbacks.

Riya Robert (2017) The stone column technique is an economical and effective method of soft soil stabilization. They are used to support embankments, large raft foundations and isolated footings. Stone columns can improve the load carrying capacity and reduces the settlement of the problematic soil. Construction can be started quickly due to the accelerated dissipation of excess pore water pressure in to the drainage formed by the stone columns Before designing the stone column, thorough subsoil investigation should be done from in-situ test results and bore logs.

Sneha P. Hirkane (2017) In view of achieving the aim and objectives of this study a detailed literature survey was being carried out. It gave us an idea regarding different methodologies adopted for ground improvement techniques. It was decided to go for the use of the software Microsoft Excel for the calculation of settlement and time period for untreated land. By using this software settlement was calculated. A comparative study was carried out between PVD and stone column. By extracting result we have concluded that PVD is costlier than stone column. It has also seen that settlement by using PVD is more than stone column.

Samuel Thanaraj (2019) observations were obtained from this paper Among the different materials used Aggregates along with the encasement gives higher strength than other materials. The values of other materials are moderately nearer to the value of stone column with conventional material aggregates. The geo-synthetic encasement prevents the contamination of stone column and thus will not reduce the friction between the stone aggregates and clay bed. The encasement prevents from bulging effect on the top portions which was studied in detail from the literatures as well. Pressure settlement response of geo-synthetic encased stone columns generally shows linear behaviour not indicating any catastrophic failure unlike the conventional stone columns.

3. GROUND IMPROVEMENT TECHNIQUES

Ground improvement and ground modification refer to the improvement in or modification to the engineering properties of soil that are carried out at a site where the soil in its natural state does not possess properties that are adequate to withstand the load of the structure. The improvement may be accomplished by drainage, compaction, preloading, reinforcement, and grouting, electrical, chemical, or thermal methods. Among the various soil stabilization procedures, the most suitable one is selected depending upon the type of soil available, time, cost involved etc.

i) Vibro-Compaction Method of Ground Improvement

Vibro-compaction, sometimes referred to as Vibro-flotation, is the rearrangement of soil particles into a denser configuration using powerful depth vibration. Vibro Compaction is a ground improvement process for densifying loose sands to create stable foundation soils. The principle behind vibro compaction is simple. The combined action of vibration and water saturation by jetting rearranges loose sand grains into a more compact state. Vibro Compaction is performed with specially-designed vibrating probes. Both horizontal and vertical modes of vibration have been used in the past.

Advantages of Vibro Compaction Method:

- Reduction of foundation settlements.
- Reduction of risk of liquefaction due to seismic activity.
- Permit construction on granular fills.

Fig 1 Vibro Compaction

ii) Vacuum Consolidation of Soil for Ground Improvement

Vacuum Consolidation is an effective means for improvement of saturated soft soils. The soil site is covered with an airtight membrane and vacuum is created underneath it by using dual venture and vacuum pump. The technology can provide an equivalent preloading of about 4.5m high conventional surcharge fill. Vacuum-assisted consolidation preloads the soil by reducing the pore pressure while maintaining a constant total stress.

Fig 2 Vacuum Consolidation

iii) Preloading or Pre-Compression of Soil for Ground Improvement

Preloading has been used for many years without change in the method or application to improve soil properties. Preloading or pre-compression is the process of placing additional vertical stress on a compressible soil to remove pore water over time. The pore water dissipation reduces the total volume causing settlement. Surcharging is an economical method for ground improvement. However, the consolidation of the soils is time dependent, delaying construction projects making it a non-feasible alternative. The soils treated are Organic silt, Varved silts and clays, soft clay, Dredged material. The design considerations which should be made are bearing capacity, Slope stability, Degree of consolidation.

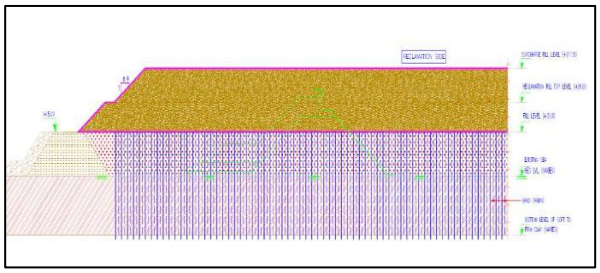

Fig 3 Typical surcharge Applied on Ground Surface

iv) Vibro - replacement stone columns

Vibro-Replacement extends the range of soils that can be improved by vibratory techniques to include cohesive soils. Reinforcement of the soil with compacted granular columns or “stone columns” is accomplished by the top-feed method. The important Vibro-replacement stone columns are Ground conditions, Relative density, Degree of saturation, Permeation.

The stone columns and intervening soil form and integrated foundation support system having low compressibility and improved load bearing capacity. In cohesive soils, excess pore water pressure is readily dissipated by the stone columns and for its reason, reduced settlements occur at a faster rate than is normally the case with cohesive soils.

There are different types of installation methods which can be broadly classified in the

Following manner:

- Wet top feed method
- Dry bottom feed method
- Offshore bottom feed method

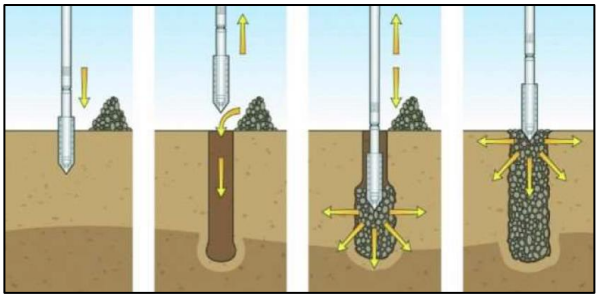

Fig 4 Step by Step Stone Column

4. CONCLUSION

Ground improvement and ground modification refer to the improvement in or modification to the engineering properties of soil that are carried out at a site where the soil in its natural state does not possess properties that are adequate to withstand the load of the structure. From this research study it is concluded that the settlement has been decreased by using encased stone column and Bulging failure is avoided. In case of bearing capacity it is concluded that bearing capacity of soil has been increased of by casting encased stone column. The rapidly increasing cost of construction and numerous environmental constraints often placed on a project have greatly encouraged the in-situ improvement of marginal sites. Stone columns are one method of ground improvement that offers, under certain conditions, an alternative to conventional support methods in both weak cohesive soils and also loose silty sands. For each ground improvement problem, however, all feasible design alternatives must be thoroughly evaluated before selecting the most cost effective method.

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