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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

I. INTRODUCTION

A successful construction project is one that is completed on time, within budget, meets specified standards of quality, and strictly conforms to safety policies and precautions. To desired ground capacity are very essential to bear heavy structure in safely for entire project life. It would be possible when the ground had enough property to fulfill the requirement. Every time same soil will available at every location. In such situation, it would be better to replace or bypass such type of soil strata or improve characteristic of soil for the best solution for such construction project site. Aim of this thesis is, study the various construction method adopting for improve the soil or ground. Every method had its own pros and cons, which will help to decide the most suitable method for problematic soil to improve its 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.

1.1 Need for Ground Improvement

Generally Engineers design Foundation and other structures basing on soil investigation. If soil good at lesser depth shallow foundation can be laid, if hard stratum available at higher depth, Deep foundation can be laid. In some cases, Deep foundation becomes uneconomical, it becomes a problem practically. So there need arises to improve the ground conditions by ground improvement. However, it is also costly but proved to be cost effective many times. Ground improvement is rapidly developing filed because good sites for construction are limited day by day. So improving characteristics of soil at site that consists of increasing shear strength, decreasing compressibility of soil. So that Bearing capacity increases which reduces settlements.

As more and more land becomes subject to urban or industrial development, good construction sites and borrow areas are difficult to find and the soil improvement alternatives becomes the best option, technically and economically.

Where a project encounters difficult foundation conditions, possible alternative solutions are:

- Avoid the particular site: Relocate a planned highway or development site.
- Design the planned structure accordingly: Some of the many possible approaches are to:
 - Use a raft foundation supported by piles,
 - Design a very stiff structure which is not damaged by settlement
 - Or choose a very flexible construction which accommodates differential movement or allows for compensation

- Remove and replace unsuitable soils: Remove organic topsoil, which is soft, compressible, and volumetrically unstable. This is a standard precaution in road or foundation construction.
- Attempt to modify the existing ground.

II. STUDY AREA

2.1 Coastal Road, Mumbai

To understand the Ground Improvement technique and results, here are one case study discussed. Project Name is, "Mumbai Coastal Road Project", one of the challenging infrastructure projects in India. After successful connection of Bandra-Worli Sea link project, the remaining shore of Mumbai is also planned for utilize for suitable transportation mode.

Municipal Corporation of Greater Mumbai proposed to develop a coastal road project (MCRP) from Princess street flyover to Kandivali junction over a length of approximately 29km to ease the traffic congestion in Mumbai and to create recreational spaces. This project is being implemented in 2 phases namely South and North. South phase starts at Princess street flyover and ends at Worli end of Bandra Worli sea link (BWSL). This phase is divided into 3 Packages



Fig 1 Coastal Road, Mumbai

2.2 Data Collection

Though the term Ground Improvement has been familiar to Civil Engineers, the design approach is still empirical, mostly based on past experience. Well defined design procedure, constructions procedure and code provisions are yet to be developed. In the absence of above, execution of the same is difficult and sometimes lead to contract disputes.

III. VIBRO STONE COLUMNS

Vibro Stone Column are constructed by using a vibrator to fill in designed hollows with granulated gravels of distinct dimensions. This takes place when construction is initiated in areas of loose soil. The weak soil cannot bear the heavy loads of the structure due to its low bearing capacity. The construction of the Vibro stone columns is one of the most versatile techniques which is used for the engineering of the ground. The force of the vibrator, along with water jetting motion, bonds the granules into a compact and dense composition. This high-tech method can help the soil achieve a relative denseness of about 70-80% more than the original density of said ground.

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 an 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

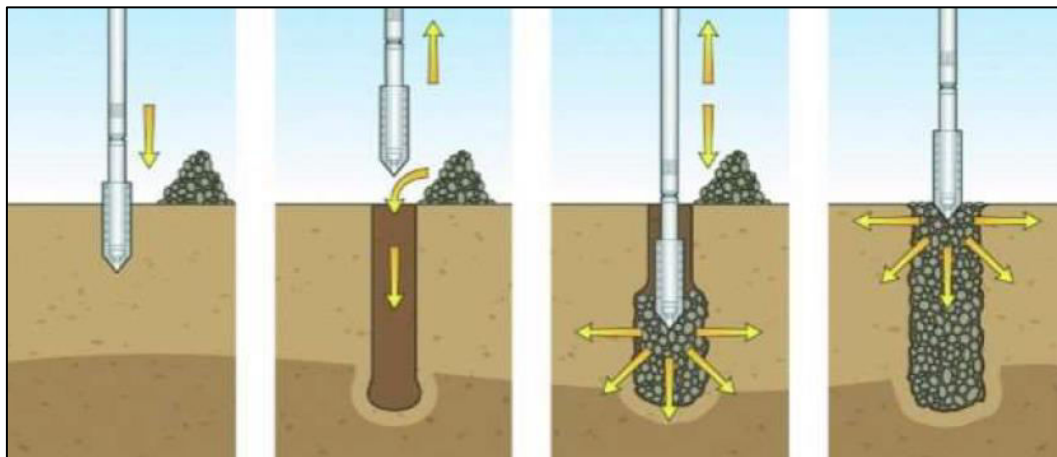


Fig 2 Step by Step Stone Column

3.1 Significance

The use of **Vibro Stone Columns** helps cut down the soil’s compressible and permeable factors to make the construction of **superstructures** easily possible. This is required because not all soil types can bear the heavy loads of the structures. The vibratory procedure of making and inserting **stone columns** into naturally weak soils moderates soil settlement issues. **Vibro stone columns** help to increase the load-bearing capacity of the soil. The **Vibro stone columns** help to minimize the size of the foundation required for the structure, due to which the overall cost of the project gets reduced. The stone column helps to densifying the soil through vibration and inserting the stone column into the soil and reinforcing the soil to create a soil mass that should be stiff.

There are various applications of Vibro stone columns in civil engineering that are as follows.

1. The stone columns are used in the rail, road embankments, power plants, bridge approaches, and abutments.
2. It is used in the construction of the foundation of lightweight structures, Industrial warehouses, and retaining walls.
3. Vibro Stone Columns help in implementing ways to maintain adequate bearing grades for the foundation of a building.
4. Vibro Stone Columns possess higher angles of inner friction and are firmer than the surrounding soil.
5. This promotes the shifting of load to the stone columns rather than inflicting the load on the weak soil.
6. It helps to reduce the settlement of the soil foundation.
7. The use of Vibro Stone Columns is applicable to soft soil grounds like sand, clay, silt, and other non-homogeneous soils.
8. Vibro Stone Columns help in cutting down compressible and permeable factors of such types of soil.

9. This method aids radial draining, thus improving the durability of constructions done on various naturally weak soils.
10. It also aids the prevention of damage at the work site by sustaining a drainage path, hence helping improve ground strength.
11. This type of stone column is best suitable for sandy soils.

IV. VIBRO CONCRETE COLUMNS

This technique involves construction of concrete columns with a bottom-feed, down-hole vibratory probe to transfer loads through weak strata to a firm underlying stratum. A bottom-feed, down-hole vibratory probe is lowered through the weak strata to the underlying firm stratum and granular bearing soils densified by the vibrator. Concrete is then pumped through the bottom-feed tremie tube. The vibrator is raised and lowered several times to form an expanded base or bulb and then raised to the surface as concrete fills the void created during extraction. Typically, the vibrator also re-penetrates the top of the column to construct an enlarged head. Once completed, the columns can be trimmed and reinforcement placed as required.

Vibro rigs can be fully instrumented with an on-board data acquisition system. Data from the system, such as amperage and lift rate, can then be recorded and displayed in real-time alongside specified target values on an in-cab monitor. This monitoring allows the operator to correct any deviations in real-time during the construction process to keep the vibro compaction within project specifications.

VCCs are a development made from adapting the bottom feed Vibro Stone Column method and can be used as a ground improvement or piling solution. As a ground improvement solution the VCCs are suitable for use in weak and organic soils or where environmental considerations and contaminants preclude the use of permeable stone columns. As a piling solution they act as cast in-situ load bearing piles and they can be installed with enlarged bases and heads for tying to pile caps or ground beams. Column diameters vary according to the soil conditions, but generally the weaker the soils, the larger the column required

- Ideal on brownfield sites where spoil removal is to be avoided
- A good alternative to stone columns where peat and organic soils are prevalent
- Suitable where founding at a high level is required to avoid boring into aquifers

Can be used to support foundations and floor slabs for all types of structures, including houses, offices, commercial and industrial units, tanks etc.

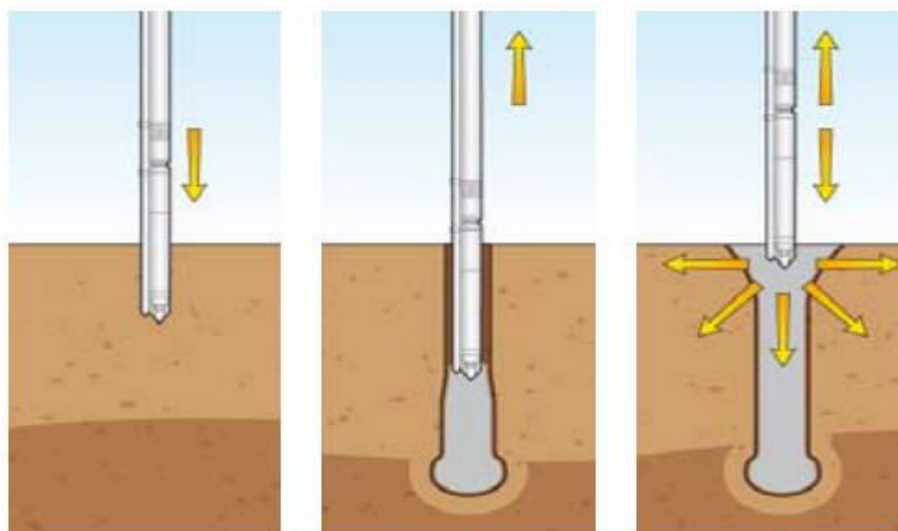


Fig 3 Typical Section for VCC method

V. COST OF SOIL IMPROVEMENT TECHNIQUES

Most of research investigated the effect of using different soil improvement techniques on increasing soil bearing capacity and /or decreasing the expected settlement while, a few research considered the cost of foundation works as one of the governing factors when selecting between different soil improvement techniques. The Cost Comparison is not prime factor while executing very important project. The cost comparison between concrete Method & Stone column method.

Table 1 Concrete Column Estimate

Column	No of Column	Dia	Length	Quantity
	1			
		0.3	30	2.1195
VOLUME OF CEMENT			0.3242835	
NO. OF BAGS			10.3	
COST OF ONE BAG			350	
TOTAL COST			3593	
VOLUME OF SAND			0.9728505	
SAND IN BRASS			0.347446607	
COST OF BRASS			3500	
TOTAL COST			1216.063125	
VOLUME OF AGG			1.945701	
AGG IN BRASS			0.694893	
COST OF BRASS			1800	
TOTAL COST			1250.808	

Table 2 Total Cost Concrete column

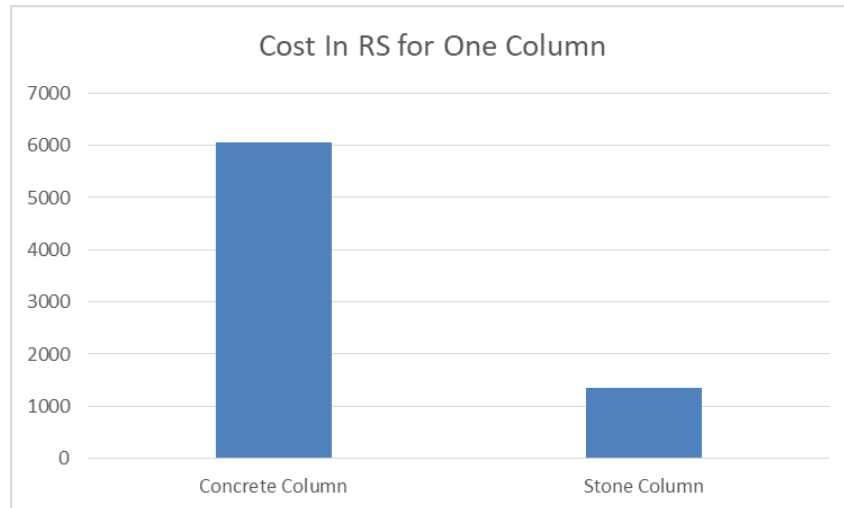
ITEM	COST
Cement	3592
Sand	1216
Aggregate	1250
Total	6059

Table 3 Stone column Estimate

Stone Column	No of Column	Dia	Length	Quantity
	1			
		0.3	30	2.1195
VOLUME OF STONE			2.1195	
AGG IN BRASS			0.748939929	
COST OF BRASS			1800	
TOTAL COST			1348.09	

Table 4 Cost In Rs For One Column

COST IN RS FOR ONE COLUMN	
Concrete Column	Stone Column
6059	1348



Graph 1 Cost In Rs For One Column

Above fig shows the cost comparison of the concrete and stone column in which stone column method is more economic than concrete column by cost comparative.

VI. CONCLUSION

There are many available improvement techniques that can be used for the purposes of increasing bearing capacity, enhancing shear strength and decreasing consolidation settlement of saturated medium clay.

In the point of view of feasible for execute on site, reliable results, Available resources, time period for ground improvement all are compare to conclude our requirement. Hence the MCRP project already have huge reclamation quantity. The reclamation material used on site natural crush stone aggregate up to 100 mm down size with almost 30 % fine to achieve minimum 95% compaction. The material required for Stone column not much differ only 40 mm down size natural crushed stone aggregate only. So no any especially procurement required additionally. This Material were easily available from same quarry and royalty only need to pay. The Overburden already planned with same material, which may further will reuse for reclamation work.

This method is economical as compare to other method. The natural resource material only use. This also Environment friendly & permanent solution.

Stone column technique provide very stable ground surface, which can bear great load. This surface not only helpful for construction but also for Heavy machinery movement.

Stone columns can be environmentally friendly because they use natural materials and are economical. Here are some other benefits of stone columns

Numerous instances arise where the soil at many sites at shallow depths are not having required properties to support proposed structures. In some situations, poor soil conditions may pose problem for the integrity of existing structures. In response to these needs special techniques for the in place treatment of soils have been developed and are practical effectively. Among the several methods the techniques of stone column is one popular since the methods require less time to implement and improvement is quicker The Coastal zone in Mumbai region where depth found up to 5 m, stone column method very suitable and easy to execute. This method is Cost saving as compare to other method. No special material required for method. No special NOC required from any government authority for execute same This is time saving also. No special climatic effort required

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