STABILIZATION OF SOFT SOIL USING STONE COLUMN – THE REVIEW

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ABSTRACT

Ground improvement techniques based on stone column are broadly used in construction industries. It is the very effective method for improving the engineering properties of soil in all aspects and reduces the settlement problem in poor grounded soil such as silt, clay and silty sand. Stone columns are installed using either top or bottom feed system accompanied with or without jetted water. The stone column mainly consists of compacted aggregates like gravel or crushed stone which is aligned by the vibrator. The stone column are very effective in cohesive soil when compared to the sand and silty soil. The permeability rate in sand and aggregates are high and allow the pore pressure dissipates in short time. The commonly used methods for installing the stone columns are vibro replacement and vibro displacement. This review paper also projected for designing the effectiveness of stone column technique in problematic soil.

INTRODUCTION

Stone column are universally used to increase the bearing capacity of the soil and reduce the liquefaction potential of soil. The soil have low plasticity like silt and clay are vulnerable to liquefaction, the reinforced stone column can increase the strength and tension of soils. The pore water dissipation in stone column accelerated by volume reduction process called consolidation with the help of aggregates. In order to enhance the consolidation rate by different admixtures and materials in the stone column like quarry dust and geosynthetics etc. The main objective of this paper is to increase the consolidation rate by providing different materials along with the stone column based on the soil condition.

The stress-settlement behavior of stone column could be improved by providing the geosynthetic encasement around the stone column.

LITERATURE REVIEW

(Shiraz, et al., 2015) has aimed to study to investigate on vibro stone column has used to improve the density of loose sediments sand and expansive clays which undrained shear strength of 15 kPa or more. It cannot be appropriate for soft cohesive soil when the undrain shear strength is below 10. Stone column can be installed by non-cohesive natural soil and the stone column solutions have been proved to be more cost effective than the trench fill where the depth exceeds 2m and where the ground conditions allow.

(Eldho, et al., 2010) has carried out the study of stone column practice introduces a coarse-grained material consisting of gravel or crushed stone aggregate as the load bearing medium. The ground improvement techniques using PVD is highly suitable for saturated soft clay prone to excessive settlement. He has worked PVD along with the stone column in back
water deposits. The main advantage of PVD over stone column is to shorten the drainage path of the pore water. PVD installation requires much time as compared to stone column.

(Taube, et al., 2002) has carried out the study on vibro concrete columns for the in-situ improvement of industrial contaminated fill on soil. Concrete bottom plugs were installed at the base of each stone column to shield the underlying chalk drinking water aquifer from downward migration of water borne contaminants.

(Jamal, et al., 2015) has carried out the study of Geosynthetic encased columns (GECs) which gives the optimum results in load settlement behavior in clayey soil. The stress settlement response of the stone columns group can be improved by reinforcing them with suitable geosynthetics. By increasing the modulus of the reinforcement material could leads to increase in the overall stiffness of the GRSC group due to generation of higher confining pressure.

(Das, et al., 2013) has carried out the study on the stone column to improve the load capacity of sandy silt soil with clay in naturally consolidated state. Load test were conducted in compression testing machine for single un encased stone column in sandy soil with clay (i.e., sand = 37.29%, silt = 33.00% and clay = 29.71%) encased (with Geotextile) stone column on layered soil. In case of un encased stone column load carrying capacity increases with the increasing diameter of stone column but in unencased and encased layered soil load carrying capacity decreases with the increasing the diameter of stone column. Also, stone columns under proper conditions can greatly decrease the time required for primary consolidation. The load settlement behavior of entire loaded area is almost linear. The load carrying capacity of treated layered soil is reduces with the increase of diameter of stone column. The encased stone column in layered soil is also decrease with the increasing diameter of stone column.

(Bhushan, et al., 2004) has made an experimental study on estimating the static settlements for constructing the water storage tank to mitigate liquefaction and lateral spreading potential. A surcharge program also has been conducted to reduce post construction settlements. The measured settlement under the surcharge agreed well with the predicted settlements. The actual time required to obtain higher than 90% consolidation was near the lower range of the estimated time. Stone column installation should be at a distance of less than 12ft (3.66 m) can cause high lateral pressure and displacement of adjacent structure. The structural damage could be reduced by eliminating the vibro compaction in the depth range of adjacent structure footing and also by stone column installation should be at a distance of 16 ft or more.

(Kosho, 2000) has aimed to investigate the effect of vibro replacement technique on the cohesive, mixed and layered soil which do not densify by means of vibration alone. In their project beta vibrator was used for bottom feed vibro replacement technique which is entirely “dry method”. Stone column techniques are proved to be more cost effective than trench fill in excess of 2m depth, and other ground improvement methods such as preloading and vertical drains.

(Shenthal, 2004) has carried out the study of densification of saturated silty soil using stone columns along with which drains are preinstalled at midpoint between the stone column in order to mitigate the liquefaction effects. Stone column has served as pathway for drainage of pore water and relieve the excess pore pressure during the earth quake and installation of stone column. It includes two criteria that excess pore pressure development and concurrent description in order to increase the density of soil by vibration induction and cavity expansion. Post improvement density could be obtained by the coupled effect of vibration induction and cavity expansion is higher than the cavity expansion alone.

(Mahoney, et al., 2014) has investigated on the case study of existing repair building for further ground improvement of soil through stone column in densely populated residential surrounding. In order to avoid the vibration and noise, they developed a new screw displacement technique for installing the stone column. This method has a advantage of no vibration and to suppress liquefaction during seismic shaking. The design of the stone column has been arrived with 600m diameter on a 1.85m triangular spacing with replacement ratio of 10%.

(Hussin, et al., 2009) has carried out experimental study on 13 soil model tests have been made at 27% water content and 9KPA undrained shear strength to analyse the nature of behavior under loading. 1 model for untreated soil, 3 model for soil treated with stone columns and 9 models for soil treated with dynamic compaction using different drop weight (2 kg, 3 kg and 5 kg) and drop height (500 mm, 750 mm and 1000 mm) finally in comparison, the treated soil has reduction in settlement ratios were 69% and 178% at applied stress of 30 kN/m² for the soil models treated with dynamic compaction (5 kg drop weight) and 3 stone column respectively and no consideration effect of drop height in dynamic compaction.

(McCabe, et al., 2007; Suriya, et al., 2016) has discussed the vibro-replacement process in stone
column for soft estuarine and alluvial soil to improve the properties at shallow depth for providing the standard foundation. Vibro replacement stone column have been installed by two different methods based on ground condition. The first one is top feed system and their corresponding stone size is 40 to 75 mm. the second one is bottom feed method and the stone size which is used in this method are in the range of 15 to 45 mm. it have been more cost effective than trench fill in excess of 2 m depth or preloading or vertical drains.

(Saraglov, et al., 2009) has examined the highway road in order to improve the poor geotechnical properties of sub soil and reduce the water level in soft clay and plasticity. The embankment was constructed for the height of 3m and settlement in the untreated ground was estimated at 15 cm in 16 months. In order to reduce the preconsolidated settlement, stone columns are installed to a depth of 14 meter and parametric analysis was performed for different replacement ratio and it was reduced to 7 cm in 4 months.

(Mani, et al., 2013) has attempted the stone column in coastal area to improve the bearing capacity of soil. In order to reduce the rapid consolidation rate due to dissipation of excess pore water pressure into the drainage path formed by stone column. He has designed the stone column based on bore log report by penetration test. To reduce the damage due to vibration, stone column were installed at a distance of 4.87m or more.

(Guétif, et al., 2007; Suriya, et al., 2014) has reported based on improvement of soft soil by stone column is due to 3 factors, the first one is inclusion of stiffer column materials such as crushed stones, gravel and other matters in the soft soil. The second factor is to improve the density of soft soil during the installation of stone column. The third factor, is stone column is acting as vertical drain. It can made changes in both the material properties and state of stresses in treated soil mass.

(Mokhtari, et al., 2012) has investigated on stone column in soft cohesive soil and reported that stone column has been able to bear isolated footing and large raft footing. It can also have particular application in soft soil such as normally consolidated clay, silt and peat. It is installed on volume displacement basic excavating a hole with specified diameter and depth.

(Malarvizhi and Illamparuthi, 2004) has investigated the stone column, encased by Geogrid on the soft marine clay. It has been tested and compared with conventional type stone column by varying the types and slenderness ratio of Geogrid. The granite chips were are used as a backfill material for the column and the Geogrid which consisted of netlon curtain having aperture 1 mm × 1 mm and 4 mm × 4 mm it has been tested for the load bearing capacity under two conditions i.e., floating and end bearing stone column. The performance of treated stone column is given 2 to 3 times than untreated stone column.

(Niroum, et al., 2011) has investigated reinforced stone column for improving the load bearing capacity of weak soil. The area replacement ratio of the stone column is defined as area of stone column to the tributary area per stone column. The coverage should be extended beyond the perimeter of the proposed structure to account for stress spread the number of mesh which is ductile in nature. The geosynthetic covering also avoid the contamination of the stone column and it would not minimize the friction between stone and clay soil.

(Ismail, et al., 2014) has carried out study on the material such as aggregate and sand which is used in the stone column construction accelerate the rate of consolidation in soft clay. Both the materials were also pore water pressure to dissipate in cohesive soil. Compare the materials for rate of consolidation under plaxis software. The coefficient of consolidation (Cv) for the sand is higher than the aggregate. Sand column is a suitable material could be used for increasing the consolidation rate and reducing the time.

(Salahi, et al., 2015) has evaluated the stone column based on liquefaction phenomenon. The excess pore pressure water increases during cyclic loading when the stone columns are constructed in silty sand with high degree of fine particles. The efficiency of the stone column is remarkably come down. When the stone columns are constructed on silty or clayey soils with low plasticity are vulnerable to liquefaction. He has suggested that the fly ash reduce the danger during liquefaction.

(Isaac, et al., 2009) were studied the performance of stone column based on the influence of material which is used in the installation by laboratory experiments. Five material were studied for this purpose based on the grain size, they are stones, gravel, river sand, sea sand and quarry dust. Among these, river and sea sand were no significant difference in the load deformation behavior of soil. Gravel is more effective than the sand. Quarry dust is effective in load deformation characteristics of soil. The spacing of the column also plays an important role in affecting the load deformation characteristics.

CONCLUSION
- During seismic vibration, stone columns were act as drainage for pore water and it helps to release the earthquake vibrations.
• In the highly populated residential areas, a new screw displacement stone column was developed to reduce the noise level and vibrations.

• To expedite the consolidation time in soft soil vertical drains are installed by the side of preloading with surcharge or vacuum pressure.

• The contamination of stone column could be prevented by encasing the stone column with geosynthetics and it reduces the friction between aggregates and surrounding soil.

• In the case of low permeability soil, wick drains were installed in between the two stone columns to increase the consolidation rate.

REFERENCES


