BEHAVIOUR OF COMPACTION SAND PILE AND STONE COLUMN IN FINE SAND WITH CLAY

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ABSTRACT: A detailed experimental study on behaviour of a compaction sand pile and a stone column in a soil sample of fine sand containing various percentages of clay. Laboratory tests are carried out on compaction sand piles as well as stone columns of size 25mm diameter installed in the reconstituted saturated soil. The mini plate load tests are conducted and the load settlement behaviours are observed. It is found that when the clay content is increased up to 20% the percentage of improvement is increased. From the results it can be concluded that even with small percentage of clay present in the loose fine sand sample, ground improvement by stone column is highly preferable than compaction sand pile.

INTRODUCTION
In view of the increasing developments in coastal areas, a number of construction activities are under taken in these areas. Most of this area contains loose sand of uniform gradation with different percentage of clay as the top layer. Replacing this stratum of loose sand deposit during the construction of structures may not be economical. Deep foundations used to transfer loads to the dense stratum are costly. So we need to consider the densification or improvement of the top loose stratum that could be used as the load bearing stratum. Improvements are being achieved by compaction sand piles in the case of loose sand stratum and stone columns in the case of clays.

Improvement of loose sand is generally carried out by compaction sand pile method. And this densification is checked by conducting SPT tests at the site. In general, after the installation of sand pile this improvement method is very effective mainly in sandy soil. Also it is found from our experience that the percentage of improvement, in the fine sand containing some clay and silt is less. This paper deals with such field situations in which loose sand contains various percentage of clay.

In practice for clayey soil, soil improvement is being carried out using stone column method. Hence an attempt is carried out to check whether loose sand containing various percentage of clay can be improved using stone columns.

Thevanayagam et.al studied the effect of fines and confining stress on undrained shear strength of silty sands. The experimental data indicate that the undrained shear strength is dependent on the intergranular void ratio and intergranular relative density. This intergranular void ratio and intergranular relative density depends on the presence of fines [5].

Sustainability of improvement techniques depends upon the percentage of clay present in the loose sand stratum [2].

Moh.et.al. studied the use of compaction sand piles for soil improvement to reduce the liquefaction potential [3]. A P Ambily et. al. studied the behaviour of single stone columns on soft clays [1].

Shadi S Najjar et.al. studied the effect of sand columns on the undrained load response of soft clays. The experimental data indicate that the improvement of undrained shear strength due to insertion of sand columns is relatively negligible beyond a critical height of 6Dc (Dc diameter of column) [4].

The present study has been carried out to determine the improvement behaviour of compaction sand piles and stone columns in fine sand containing different percentage of clay.

LABORATORY TESTING PROGRAM
All experiments are carried out on 25mm diameter stone column and compaction sand piles in saturated reconstituted soil sample. The tests are conducted in a cylindrical tank of 280mm height and 210mm diameter. The height of the compaction sand pile and stone column is limited to 150mm. The size of plate used is 25mm thick and 50mm in diameter.

Test Setup
A typical arrangement of the experimental set up is shown in Fig. 1. Both compaction sand pile and stone column are inserted into the soil sample by displacement method. Load was applied through a proving ring at a constant strain rate of 1.25mm/minute. Displacement is measured by using a dial gauge.
Properties of materials
The materials used for this study are fine sand taken from Kaniyapuram beach (Thiruvanathapuram), bentonite clay, and graded coarse sand for compaction sand piles and stone chips for stone columns.

Fine sand (FS)
The fine sand taken from the Kaniyapuram beach is the soil sample on which improvement is tested. The clay content is negligible (0.1%). The effective diameter \(D_{10}\) is 0.25mm, the uniformity coefficient \(C_u\) is 1.7 and the angle of internal friction \(30^\circ\) (at \(e_{max}\)).

![Fig. 1a Sieve analysis graph fine sand](image)

Clay(C)
The bentonite clay is used which is having a specific gravity of 2.68, liquid limit of 294%, plastic limit of 52%, clay content of 80%, silt content of 18% and sand content of 2%.

Coarse sand
Coarse sand was used for formation of compaction sand piles (CSP). In order to obtain proper gradation, the particles belonging to the grades in between 4.75 mm & 2.36mm, 2.36mm &1.18mm, and 1.18mm & 0.6mm are equally added.

![Fig. 1b Sieve analysis graph of coarse sand](image)

Preparation of specimen
A known percentage of bentonite clay powder is mixed with fine sand in dry condition. The fully saturated sample was filled into the cylindrical mould in three layers. Each layer is compacted to attain the required density. The top surface is levelled with a trowel. A removable driving shoe is fixed initially on the top of prepared sample. The shoe is inserted into the soil up to the desired depth using the hollow PVC pipe of outside diameter of 25mm. Then hollow PVC pipe is removed partially and filled with either coarse sand (for CSP) or stone chips (for SC). In the formation of stone columns, one third height is filled and fifteen blows are given to each layer. The quantity of stone chips used is also the same for all the tests. The casing is removed slowly at the time of filling the next layer. In all the sample preparation the dry density of the sample (with clay/without clay) is maintained as 1.770gm/cc. The sample prepared is shown in Fig. 2.

![Fig. 2 (a) PVC casing with shoe. (b) Prepared samples](image)
The load deformation behaviour of each sample having different percentage of clay content is noted up to a deformation of 10mm. The improvement due to insertion of compaction sand pile or stone column is also noted.

ANALYSIS OF TEST RESULTS
The results presented in graphs (Fig. 3) are analysed to investigate the improvement behaviour of soil sample with different percentage of clay at different settlements of 5mm, 10mm, and at failure load condition also.

From the test results it was clear that the improvement percentage of soil due to insertion of compaction sand pile or stone column is increased with increase in clay content up to 20%. Further increase of clay content reduces the percentage of improvement of stone column while the increase of percentage of improvement of compaction sand pile was continued. Figure 4(a) & 4(b) shows the behaviour of percentage of improvement.
The improving capacity of CSP and SC in fine sand sample is around 25% & 118% respectively (Fig.3a). Small percentage of clay presence slightly affects the properties of the sample. Therefore the improvement percentage showed a slight increase of 27% & 235% (Fig.3b). Further increase of clay percentage directly affects the soil properties which increase the improvement percentage as 255% & 560% (Fig.3c, Fig.3d & Fig.3e). When the clay percentage exceed a limit beyond 20% in this case, the interaction between the coarser stone chips and flocculated clay particles are decreased causing reduction in improvement percentage of SC as 365% (Fig.3f).

From the results it was found that the settlement of non densified sample at failure load is increased with increase in percentage of clay, while in the case of samples with compaction sand pile or stone column the settlement at failure load is decreased.

CONCLUSIONS

For a fine sand sample, when the percentage of clay content increase from 5% to 20%, the improvement due to CSP at failure load condition is increased from 28% to 301%, and the improvement due to SC at failure load condition is increased from 365% to 703%.

When the clay content increases 20% to 25% in the fine sand sample, the improvement due to CSP increased from 301% to 359% but improvement due to SC is decreased from 703% to 445%.

Thus from the results it can be concluded that even with a small percentage of clay in the loose uniform graded fine sand sample, densification by stone column is more preferable than compaction sand pile.

REFERENCES