Behavior of Stone Column improved Clay soil under static loading-A numerical exploration

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Abstract: Problematic soil which cause extra problems from engineering point of views which result in its composition or environmental conditions change. The weak subsoil deposits like soft clay pose the low bearing capacity and more settlements over long periods of time. The stone column technique is better, economical and cost-effective method of soft soil stabilization. They are used to support embankments, large raft foundations and isolated footings. Numerous researchers have just completed various vertical stacking probes stone column balanced out clay bed and have discovered that expands bearing capacity of delicate clay, diminishes displacement and changes the conduct of burden settlement. In the current study, a 2D finite element model is completed to evalute how the delicate clay soil balanced out by stone column are affected by the vertical burdens. Stone column were intended for examinations with fluctuating in their angle proportions (change in estimations of length, L and breadth, D) of stone column. The effect of floating stone column and end bearing stone segment on delicate clay is in like manner controlled by using various L/D ratios. Besides, the present outcomes express how the heap conveying limit of stone column is differed by changing in the angle proportions of the stone column. Likewise ends were drawn that bulging impact of stone column plays a vital role in conveying vertical burden.

Keywords: Stone column, soil, plaxis 2d, l/d ratio, bulging effect.

I. INTRODUCTION

Soil plays an important role in sustaining life on the planet. The actual amounts on which the soils get formed depends upon the type of the soil. Problematic soil which cause extra problems from engineering point of views which result in its composition or environmental conditions change. The weak subsoil deposits like soft clay pose the low bearing capacity and more settlements over long periods of time. A variety of methods of ground improvement techniques have been successfully applied in several cases to reduce characteristics of problematic soil. Some of the techniques are well established because of sound theoretical support, successful implementation and satisfactory performance. Those techniques are Consolidation by preloading and vertical drains, Granular piles / stone columns, Electro – osmosis, Dynamic compaction, Jet grouting, Blasting, Heating and Freezing , Lime piles. The stone column technique is better, economical and effective method of soft soil stabilization. They are used to support embankments, large raft foundations and isolated footings. It can build the heap conveying limit and decreases the settlement of the tricky soil.

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Also, a construction can be started quickly due to the accelerated dissemination of abundance pore water pressure in to the drainage formed by the stone columns which makes it better than other techniques. In this study, the load displacement behavior of stone column under static pressure is determined through Plaxis 2D software. This study explores the load displacement behavior of the stone column, such as varying diameter of stone segment, change in length of the stone column and varying L/D Ratios.

II. NUMERICAL ANALYSIS OF STONE COLUMN WITH VARYING LENGTH OF THE STONE COLUMNE, VARYING DIAMETER OF THE STONE COLUMN AND VARYING LENGTH / DIAMETER RATIOS

In this current study, 24 stone column models was generated. PLAXIS 2D software Version (8.2) were used for numerical analysis. The materials used in this model are Clay soil and Stone chips. Essential properties were acquired from lab test and a few qualities are from past looks into and analyzed on the basis of various field conditions such as varying length of the stone column, varying diameter of stone column and length / diameter ratios.

Table 1: Properties of Virgin Clay Soil

S. No	Properties	Value	Remarks
1	Specific gravity	2.53	-
2	Free swell Index (%)	60	High expansive nature
3	Liquid Limit (%)	62	-
4	Plastic Limit (%)	21	-
5	Plasticity Index (%)	41	IP > 17% high plastic
6	Shrinkage Limit (%)	8.37	-
7	Soil classification (USCS)	CH	Highly compressible clay
8	Maximum dry density(g/cc)	1.69	-
9	Optimum moisture content (%)	19.7	-

Mohr Coulomb model were utilized to dissect the stone segment balanced out clay bed. The soft clay and the stone, both are demonstrated by the Mohr-Coulomb model which is accessible in Plaxis 2D software.

Parameter used in Mohr Coulomb model for clay are C=17.5 kPa, γ=16.9 kN/m^3, E=881, v=0.2 and for stone chips are E=2700 kPa, v=0.3, γ=17, ϕ'= 41.1° and c'=0.1. The undertaking manages the displaying, investigation and investigation of a stone section for huge structures. Stone section have been demonstrated and dissected by shifting length and fluctuating distance across. The product utilized for the demonstrating and investigation are FEM programming PLAXIS 2D. The outcomes for load versus settlement have been gotten.

MODELLING

The limited Element investigations are performed utilizing the economically accessible limited component programming Plaxis 2D. Twenty-four models were done to contemplate the impact of shifting length, differing distance across and changing L/D proportion. Material properties, limit conditions were appointed to all the models. As a rule, Finite component work yields progressively precise outcomes, subsequentlyfor exact outcomes work is utilized in the model. Prescribed settlement 10 mm applied to the model and stacking zone was 1.05 times the distance across. The limited component model is a numerical examination method to get approximated answers for some issues. In PLAXIS limited component code, fifteen nodded triangular components were picked for lattice. Following stage is giving the material properties for components utilized in the model. At that point after 10 mm prescribed settlement is given to the model on the highest point of the establishment by fixing the base of the dirt medium with fixed limit conditions. In the following stage coinciding isgiven with first arranged organized sort work. At that point at long last work must be run for running the investigation of the model.

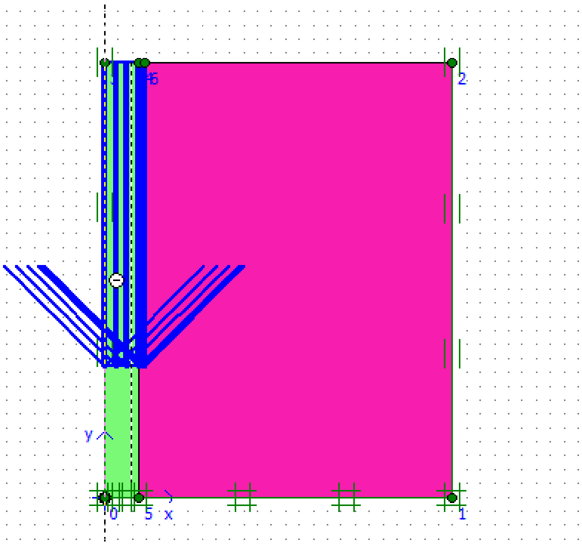

Figure 1: End Bearing Column

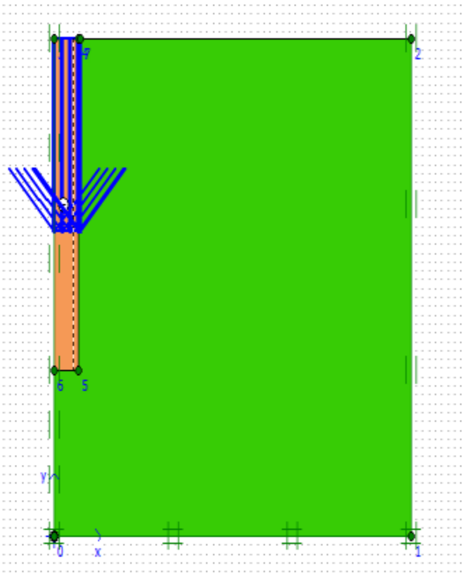

Figure 2: Floating Column

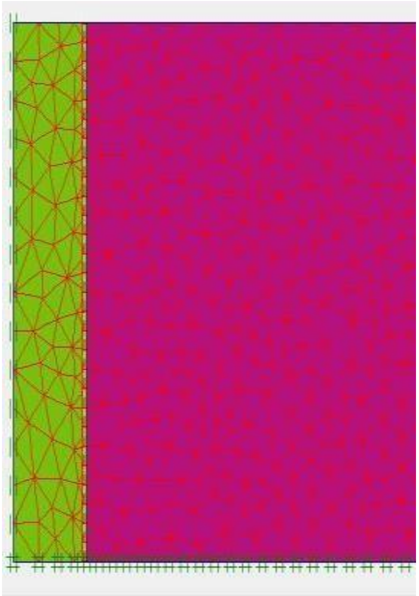

Figure 3: Meshing

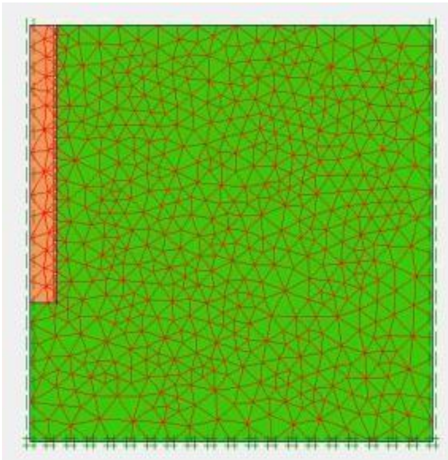

Figure 4: Meshing

III. RESULTS

A. Effect of L/D ratio on Vertical Load Carrying Capacity on stone column

Table 2. Measurements of stone column

END BEARING STONE COLUMN				
S. No.	DIAMETER (mm)	SETTLEMENT (mm)	LENGTH (mm)	L/D RATIO
1	50	10	250	5
2	50	10	375	7.5
3	50	10	500	10
4	50	10	625	12.5

The heap settlement bends for various Aspect proportion of End bearing stone section are appeared in Figure 5. To consider the impact of L/D proportion of the stone segment, a progression of investigation are completed in Plaxis and the comparing results are introduced in table 3. The impact of proportion of the length of stone section [L] to the measurement of the stone segment [D] (Aspect proportion) was examined by Finite component programming. The Aspect proportions differed as 5, 7.5, 10 and 12.5. The heap uprooting bends for various perspective proportion of stone section are appeared in figure 5.

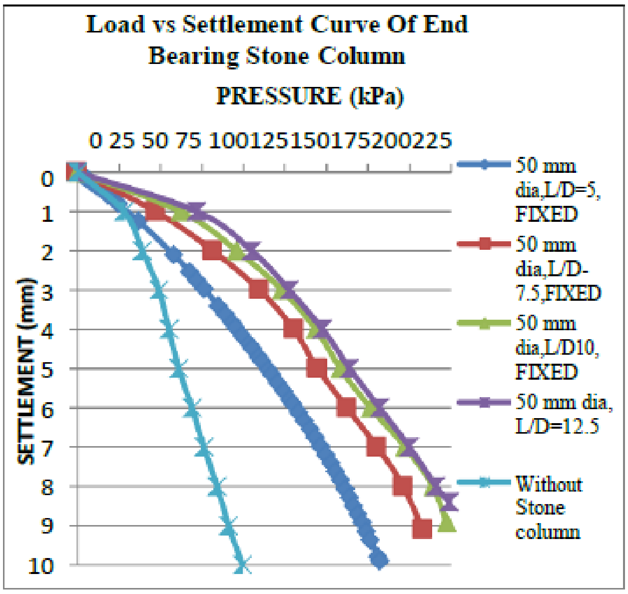

Fig 5: - Pressure vs Settlement curve for various L/D Ratio (End Bearing -50 mm diameter)

Table 3. The vertical pressure for each aspect ratio at 10 mm settlement

DIAMETER	L/D RATIO	SETTLEMENT	PRESSURE (kPa)
50	5	10	182.17 kPa
50	7.5	10	208 kPa
50	10	10	222.3 kPa
50	12.5	10	224.5 kPa

B. Effect of L/D ratio on Vertical Load Carrying Capacity on stone column

Table 4 : 75 mm diameter of end bearing stone column

S. No.	DIAMETER (mm)	SETTLEMENT (mm)	L/D RATIO
1	75	10	5
2	75	10	7.5
3	75	10	10
4	75	10	12.5

The heap settlement bends for various Aspect proportion of End bearing stone section are appeared in Figure 6. To consider the impact of L/D proportion of the stone segment, a progression of investigation are completed in Plaxis and the comparing results are introduced in table 5. The impact of proportion of the length of stone section [L] to the measurement of the stone segment [D] (Aspect proportion) was examined by Finite component programming . The Aspect proportions differed as 5, 7.5, 10 and 12.5. The heap uprooting bends for various perspective proportion of stone section are appeared in figure 6.

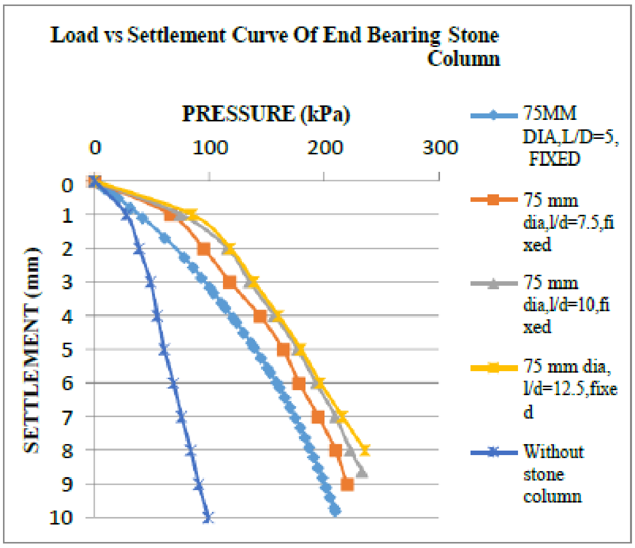

Figure 6:- Pressure vs Settlement curve for various L/D Ratio (End Bearing 75 mm diameter)

Table 5: Vertical pressure of stone column with different L/D Ratio

DIAMETER	L/D RATIO	SETTLEMENT	PRESSURE (kPa)
75	5	10	209.99 kPa
75	7.5	10	219.82 kPa
75	10	10	233.12 kPa
75	12.5	10	235.6 kPa

C. Effect of L/D ratio on Vertical Load Carrying Capacity on stone column

Table 6: 100 mm diameter of end bearing stone column

S. No.	DIAMETER (mm)	SETTLEMENT (mm)	L/D RATIO
1	100	10	5
2	100	10	7.5
3	100	10	10
4	100	10	12.5

The heap settlement bends for various Aspect proportion of End bearing stone section are appeared in Figure 7. To consider the impact of L/D proportion of the stone segment, a progression of investigation is completed in Plaxis and the comparing results are introduced in table 7. The impact of proportion of the length of stone section [L] to the measurement of the stone segment [D] (Aspect proportion) was examined by Finite component programming. The Aspect proportions differed as 5, 7.5, 10 and 12.5. Theheap uprooting bends for various perspective proportion of stone section are appeared in figure 7.

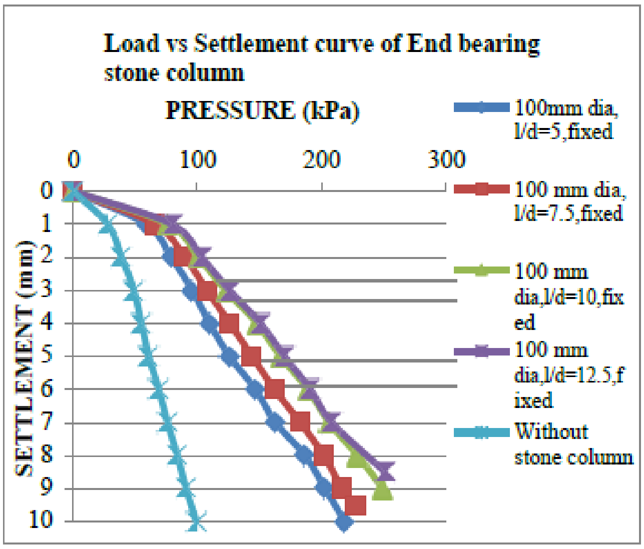

Fig 7:- Pressure vs Settlement curve for various L/D Ratio (End Bearing -100 mm diameter)

DIAMETER	L/D RATIO	SETTLEMENT	PRESSURE (kPa)
100	5	10	219 kPa
100	7.5	10	227.8 kPa
100	10	10	249.5 kPa
100	12.5	10	251.36 kPa

D. Effect of L/D ratio on Vertical Load Carrying Capacity on stone column

Table 8: 50mm diameter of floating stone column

S. No.	DIAMETER (mm)	SETTLEMENT (mm)	L/D RATIO
1	50	10	5
2	50	10	7.5
3	50	10	10
4	50	10	12.5

The heap settlement bends for various Aspect proportion of Floating stone column are appeared in Figure 8. To consider the impact of L/D proportion of the stone segment, a progression of investigation are completed in Plaxis and the comparing results are introduced in table 9. The impact of proportion of the length of stone section [L] to the measurement of the stone segment [D] (Aspect proportion) was examined

by Finite component programming. The Aspect proportions differed as 5, 7.5, 10 and 12.5. The heap uprooting bends for various perspective proportion of stone section are appeared in figure 8.

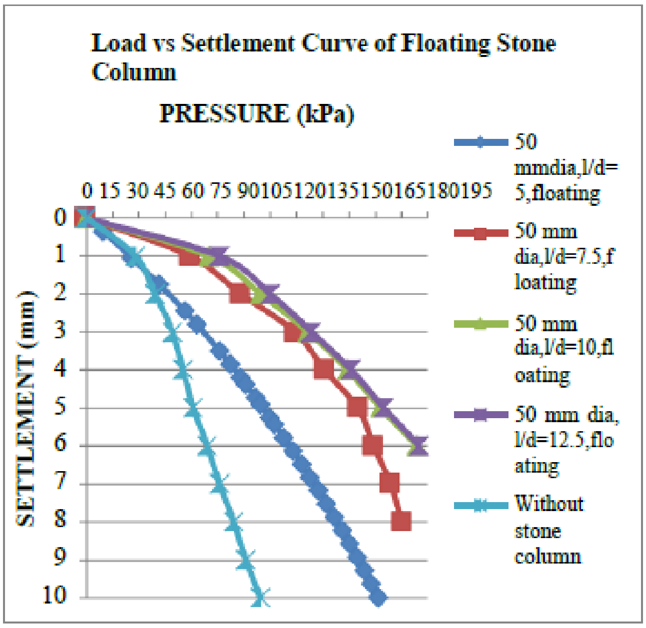

Fig 8:- Pressure vs Settlement curve for various L/D Ratios (50 mm diameter Floating Stone Column)

Table 9: Vertical pressure of Floating stone column with different L/D Ratio

DIAMETER	L/D RATIO	SETTLEMENT	PRESSURE (kPa)
50	5	10	166.83 kPa
50	7.5	10	180.36 kPa
50	10	10	188.95 kPa
50	12.5	10	190.3 kPa

E. Effect of L/D ratio on Vertical Load Carrying Capacity on stone column

Table 10: 75mm diameter of floating stone column

S. No.	DIAMETER (mm)	SETTLEMENT (mm)	L/D RATIO
1	75	10	5
2	75	10	7.5
3	75	10	10
4	75	10	12.5

The heap settlement bends for various Aspect proportion of Floating stone column are appeared in Figure 9. To consider the impact of L/D proportion of the stone segment, progressions of investigation are completed in Plaxis and the comparing results are introduced in table 11. The impact of proportion of the length of stone section [L] to the measurement of the stone segment [D] (Aspect proportion) was examined

by Finite component programming. The Aspect proportions differed as 5, 7.5, 10 and 12.5. The heap uprooting bends for various perspective proportion of stone section are appeared in figure 9.

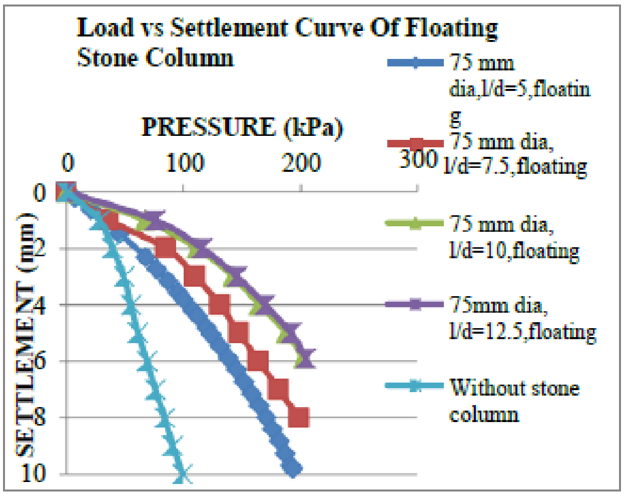

Fig 9:- Pressure vs Settlement curve for various L/D Ratio (75 mm diameter Floating stone column)

Table 11: Vertical load capacity of Floating stone column with different L/D Ratio.

DIAMETER (mm)	L/D RATIO	SETTLEMENT (mm)	PRESSURE (kPa)
75	5	10	166.83 kPa
75	7.5	10	180.36 kPa
75	10	10	188.95 kPa
75	12.5	10	190.3 kPa

F. Effect of L/D ratio on Vertical Load Carrying Capacity on stone column

The heap settlement bends for various Aspect proportion of Floating stone column are appeared in Figure 10. To consider the impact of L/D proportion of the stone segment, a progression of investigation is completed in Plaxis and the comparing results are introduced in table 13. The impact of proportion of the length of stone section [L] to the measurement of the stone segment [D] (Aspect proportion) was examined by Finite component programming. The Aspect proportions differed as 5, 7.5, 10 and 12.5. The heap uprooting bends for various perspective proportion of stone section are appeared in figure 10.

Table 12: 100 mm diameter floating stone column

S. No.	DIAMETER (mm)	SETTLEMENT (mm)	L/D RATIO
1	100	10	5
2	100	10	7.5
3	100	10	10
4	100	10	12.5

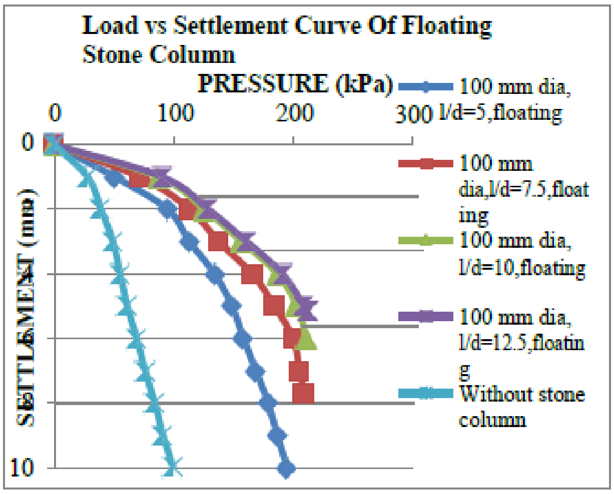

Fig 10:- Pressure vs Settlement curve for various L/D Ratio (100 mm diameter floating stone column)

Table 13: Vertical load capacity of Floating stone column with different L/D Ratio

DIAMETER (mm)	L/D RATIO	SETTLEMENT Mm	PRESSURE (kPa)
100	5	10	195 kPa
100	7.5	10	209 kPa
100	10	10	211 kPa
100	12.5	10	213 kPa

G. BULGING EFFECT

Stone column has shared higher pressure by the detached obstruction against bulging. Bulging is identified from the top to 1.5-5.2 times the diameter of the stone column.

Below figures shows the bulging effect of stone column with different L/D Ratio.

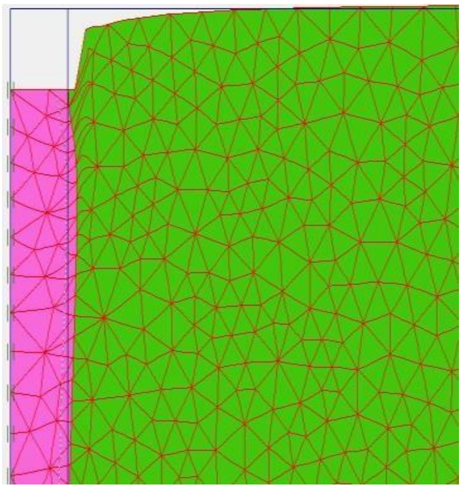

Fig 11: Bulging effect of stone column

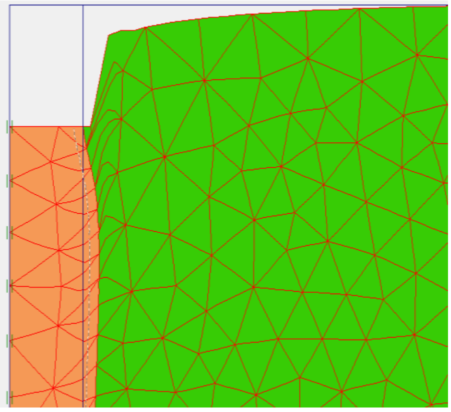

Fig 12: Bulging effect of stone column

IV. CONCLUSION

The impact of static loading on the stone column balanced out clay bed has been investigated through numerical displaying. The models were done utilizing the product PLAXIS 2D, and the models were checked. Models were then used to direct a parametric review with various Length/Diameter proportions and protruding impact tosurvey the heap conveying limit of the stone column exposed to vertical weight. On that premise the ends drawn are as per the following.

1. Analysed the difference between load settlement behavior of without stone column and with stone column stabilized clay soil.

To analysed the distinction between load displacement, conduct of without stone column and with stone column stabilized clay soil.

2. The settlement of clay soil increments with increment in pressure and it shows a ceaseless relocation at a different burden. In this manner, mean the conduct of exceptionally compressible clay.
3. A succession of burden relocation bends were gotten by numerical investigation of stone segment model with various perspective proportion (L/D) to set up the vertical burden limit under extreme conditions. Viewpoint proportions of Stone column installed clay bed assume a significant job in the vertical burden conveying limit. The expansion in the viewpoint proportion of stone segment will expand the vertical burden conveying limit essentially.
4. The settlement watched less worth when the stone column length is expanded under stacking condition. Higher the estimation of L/D proportion is, lesser the settlement.
5. Length of the stone column assumes a huge role in settlement decrease.
6. From the analysis, it is discovered that fixed stone column perform superior to floating stone column.
7. Bulging plays a significant role to carry the load and decrease settlement from the large structure.

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