Review On Model Analysis Of Stone Column

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***Abstract*:**

The rapid increase in construction activities over the past few decades have undisputedly increased the importance of ground improvement techniques. The stone column technique has been successfully applied for the foundation improvement (Ground Improvement). According to experimental and FEM research reinforcing soil by inclusion of stone columns is considered to be economical, feasible and effective in soft soils. This research aims to investigating shear strength, bearing capacity of soft soil, settlement deformation by developing large scale laboratory model. Stone column technique has been successfully applied for the foundation improvement (Ground Improvement). A rigid box with dimension: 1.0mx1.0mx1.0m (Equipped with type of soil). Experimental work will be carried out on stone column with combination like bigger diameter of single stone column, group of stone columns. The parameters are varying in this experimental and by using software investigation are length, diameter, no. of stone columns, stiffness and so on. FEM analysis will also be performed using MIDAS GTS NX software. Experimental results will validate with results from software. And formulation is also finding out using the validated results.

***Keywords*:** *Bearing capacity, Stone column, Formulation, MIDAS*

1. INTRODUCTION

The rapid increase in construction activities over the past few decades have undeniably increased the importance of ground improvement techniques. Ground improvement techniques are numerous but all aim to rectify the engineering behaviour of problematic soils so as to achieve desired properties. According to theoretical and experimental research, reinforcing soil by inclusion of granular/lime columns is considered to be economical, feasible and effective in soft soils.

The Stone-column is a useful method for increasing the bearing capacity and reducing settlement of foundation soil. Ground improvement techniques are numerous but all aim to rectify the engineering behavior of problematic soils so as to achieve desired properties. One effective method is stone-column referred to by other names such as granular column or granular pile.

The stone column technique is preferred, because it gives the advantage of reduced settlements, increase in bearing capacity, and accelerated consolidation settlements due to reduction in flow path lengths. Another major advantage with this technique is the simplicity of its construction method. Stone columns may be used in sand deposits but have particular application in soft, inorganic, and cohesive soils.

Various methods may be used for soil improvement, involving column type elements, soil replacement, and consolidation may be considered. The construction of structures such as a building, storage tanks, warehouse, earthen embankment, etc., on weak soils usually involves an excessive settlement or stability problems. So the prediction of accurate ultimate bearing capacity of stone columns is very important in soil improvement techniques.

There have been a number of valuable studies carried out on stone column, to check the bearing capacity and settlement of soil without granular columns or with granular columns. Numerous researchers have carried out numerical analysis on reinforced stone column as well as the analytical analysis also used for this work.

The many researchers have reported the performance of single and a group of reinforced stone columns through laboratory model tests and in that research by changing the parameters of stone column such as spacing of stone column, length and diameter of stone column, stiffness etc. results were observed. And that results were be validated by using FEM results.

In some previous papers the numerical results from the FEM are compared with the experimental results which showed good agreement between the results. From this study, the lack in research found for the experimental analysis for check of bearing capacity and settlement with the combination of single stone column and group of stone column with the validation of results by using MIDAS GT NX software.

2. LITERATURE REVIEW

he literature survey focuses on background of the most widely used numerical analysis by using FEM methods, experimental and analytical methods, on stone column with the encasement of geo-synthetic material. And also focuses on the

variation of different parameters of stone column and the present soil condition, various computer based programs / software's used for analysis and validation purpose to meet the objective of the study.
There have been a number of valuable studies carried out on stone column, to check the bearing capacity and settlement of soil without granular columns or with granular columns. The many researchers have reported the performance of single and a group of reinforced stone columns through laboratory model tests and in that research by changing the parameters of stone column such as spacing of stone column, length and diameter of stone column, stiffness etc. results were observed. And that results were be validated by using FEM results. In some previous papers the numerical results from the FEM are compared with the experimental results which showed good agreement between the results. There are some literature survey are focuses as follows:

2.1.1 Paper based on Experimental work

Mohammed Y. Fattah et. al. (1) 2017 explains the statistical analysis using the SPSS (Statistical Package for the Social Sciences) program from the present experimental work and previous studies and obtained a general equation. The equation is used to estimate the bearing capacity of floating stone column group installed in clays of different un-drained shear strengths and with different diameters and L/ D ratios constructed by cased bored method. The equation indicates that the most controlling parameter in the prediction of stone columns bearing capacity, qu, is the area replacement ration, As, where qu increases considerably with increase of As, i.e. decrease of spacing between columns.
MurtazaHasanet. al. (2) 2016 explain results of a series of laboratory model tests and numerical analysis carried on geosynthetic reinforced granular pile under short term loading. Unit cell concept has been adopted. Laboratory model tests were conducted on unreinforced, vertical encased, reinforced with horizontal strips and combined vertical-horizontal reinforced granular piles. The loading was applied either over the entire cylindrical tank area or only over the area of granular piles. The effects of various parameters such as reinforcement, encasement stiffness, shear strength of clay, length and diameter of granular piles have been studied. Experimental results in the form of vertical load intensity settlement relationship have been compared with that obtained from PLAXIS 3D. The results of laboratory model tests indicated significant influence of reinforcement on the ultimate load intensity of granular piles and ultimate bearing capacity of treated ground.
Mansoor Khan et. al. (3) 2016 analyse the effects of floating columns in clayey soil with silty deposits by developing small scale laboratory models. A comparison is made among lime and granular columns whereby the results of the treated ground are compared to the untreated ground. The effects of granular/lime columns on soils of different shear strengths (low-medium-high) and slenderness ratio (L/D) of columns are investigated. Based on the results, it is concluded that the granular columns gave higher strength than lime columns in the soil of low shear strength, whereas the lime columns gave more strength than granular columns in soil of higher shear strength. The composite models containing column in the center represented the behavior of interior column among a group of columns in practice. The experimental work confirmed the use of granular and lime columns as an effective ground improvement technique.
Dr. Maki Jafar Mohammed Al-Wailyet. al. (4) 2014 mention the experimental study was conducted to demonstrate the relationship between the bearing improvement ratio (which is defined as the ratio between the bearing capacity of the soil treated with stone column to the bearing capacity of untreated soil at the same settlement level) or (qtreated/quntreated) and the area replacement ratio (which is defined as the ratio between the area of cross-section of stone column and the area of soil surrounding it).The investigation was carried out using model tests of stone column with different diameters or area replacement ratio (Ar) performed inside the container with having some dimensions i.e. height. The undrained shear strength of the soil prepared in the containers. The study showed that the bearing improvement ratio were be increased while using treated stone column.
Eied M. M. et. al. (5) 2014 mention 3-D numerical model to represent the soil and the stone column under the foundation. The numerical model is based on finite element (ABACUS- program). Comparative study is performed to determine the suitable analysis to evaluate the behavior of the stone columns group below foundation. The numerical results are calibrated with in situ-measurements.
Mukul Bora et. al.(6)2014 describes the behaviour of stone column under load in soft clay bed. The group effect of the stone column was also studied in this investigate as the stone column reinforced bed was prepared in group. Based on the experimental results pressure settlement response of the stone column reinforced clay was studied. The experimental data was further used for regression analysis to fit the equation for bearing capacity of the improved soft clay bed. Both the linear and nonlinear regression was carried out and the best suited regression model was presented here in this paper. It is observed that the non linear regression model is best fitted for the stone column reinforced clay bed.
Dr. Maki J. Mohammed Al-Wailyet. al (7) 2012 describes the group efficiency of 16 model stone and lime columns installed in soft clay are calculated. These groups consist of 2, 3 and 4 columns. The tests were conducted on stone and lime columns with length to diameter ratio (L/D).A special compression machine was manufactured for carrying up these tests.. The spacing between all columns equals twice the stone or lime column diameter (D), center to center. The stone (lime) column capacity is taken as the load corresponding to a settlement equals to 50% of the diameter of stone (lime) column. The results illustrated that the group efficiency decreases with increasing the number of stone columns, also the stone columns provided higher efficiency than lime columns in the soil of shear strength, but the lime columns provided higher efficiency than stone columns.
Dr. Hussein H. Karimet. al. (8) 2009 presented the laboratory measurements of the properties of such clays and their settlements at different applied stresses. There some soil model tests have been made, considered water content and undrained shear strength, to examine their behaviors under loading .The tested models include : (1) model for untreated soil ;(3) models for soil treated with stone columns; some models for soil treated with dynamic compaction using drop weights at different drop

heights. For dynamic compaction, the behavior of soil stress–settlement analysed. Whereas, the behavior of stress settlement using stone columns reflects three stages with slow, rapid and slow(again) settlements. Where the settlements increases slowly, quickly and slowly(again) with different stages.

Mohammed Y. Fattah et. al. (9) describes research work has been done on the behaviour of embankment models resting on soft soil reinforced with ordinary and encased stone columns (ESCs). Model tests were performed with different spacing distances between stone columns and two length-to-diameter ratios of the stone columns, in addition to different embankment heights. A total of 39 model tests were performed on soil with an undrained shear strength. The system consisted of a stone column–supported embankment at different spacing-to-diameter ratios (s/d) of stone columns. Earth pressure cells were used to measure directly the vertical stress on the column for all models, and another cell was placed at the base of the embankment between two columns to measure directly the vertical stress in reinforced soft soil.

2.1.2 Paper based on FEM analysis

MehrabJesmaniet. al. (10) 2015 explain results of numerical studies carried out on behavior of pile located near soft clay slopes under undrained vertical loading conditions. A series of three-dimensional numerical models was performed for various pile geometry, different distances of the pile and slope angle. The obtained results show that, as the pile embedded length increases, full formations of wedge failure occurs and, therefore, a greater axial capacity of the pile is mobilized. In addition, by decreasing the distance of the pile from the slope crest, the lateral movement of soils increases and the lack of soils on the slope side of the pile tend to reduce the bearing capacity. Furthermore, by increasing the slope angle, the pile lateral displacement increases and, therefore, the eccentricity of the axial load on the pile will produce more additional bending moments in the pile and thereby the axial capacity reduction increases.

YogendraTandelet. al. (11) 2015 analyses the behavior of stone column by the numerical modelling of a small group of laboratory- modelled reinforced stone columns. The study is carried out considering parameters like area replacement ratio (ARR), stiffness of reinforcement material and reinforcement length. The performance of reinforced stone column group is discussed in terms of bearing ratio, (q/Cu)-settlement ratio, stress concentration factor and lateral deformation. The results of numerical analyses indicate that ARR and stiffness of geosynthetic are the governing parameters for enhancing the performance of reinforced stone column. The performance of partial reinforced stone column is close to that of a fully reinforced stone column.

Jorge Castro (12) 2014 explain 2D and 3D finite element analyses that study the performance of groups of stone columns beneath a rigid footing. Those numerical analyses show that the number of columns and their arrangement have a small influence on the load-settlement curves. This paper proposes a new simplified approach to study groups of stone columns, which involves converting all the columns of the group beneath the footing in just one central column with an equivalent area. This simplified model is used to conclude that, for settlement reduction, there is a column critical length in a homogeneous soil around twice the footing width, and high area replacement ratios beneath a rigid footing are less efficient.

Micheál M. Killeen et. al. (13) 2014 mention a 3-D finite element analysis in conjunction with an elastic–plastic soil model is used to identify the effect of variables in the design process and interactions between them: these include column arrangement, spacing, length, and Young's modulus of the column material. A simplified method is proposed to relate the settlement of small groups to a reference unit cell settlement predicted by current analytical approaches.

2.1.3 Paper based on Experimental and Numerical analysis

P. Mohantyet. al. (14) 2015 describes the soil layering effects on response of the stone column and stone column improved ground through a series of small scale laboratory tests and numerical analyses. Two types of layering systems, i.e. soft clay overlying stiff clay and vice versa are considered for the present study. The entire laboratory tests were carried out on 88 mm diameter stone columns installed in a two layered soil systems. Unit cell concept is used to idealize the behaviour of a single column within an infinite group of stone columns. Entire unit cell and only the stone column area were loaded to evaluate the stress versus settlement response of the entire improved ground and that of the stone column. Effects of the top soft and stiff clay layer thickness on the axial stress of the whole improved ground and stone column only are evaluated through laboratory tests.

MurtazaHasanet. al. (15)2016 describes the investigation and laboratory model tests were carried out on granular piles (floating and end bearing). The effects of rein-forcement, undrained shear strength of clay, encasement stiffness, diameter and length of granular piles were studied. And the vertical load intensity-settlement plots from laboratory model tests were compared with that obtained from PLAXIS 3D. And this analysis has been conducted to estimate the ultimate load intensity of granular pile.

2.1.4 Paper based on Analytical Method

J. NazariAfsharet. al. (16) 2016 explains an imaginary retaining wall is used such that its tretches vertically from the stone column edge. A simple analytical method is introduced for estimation of the ultimate bearing capacity of the stone column using Coulomb lateral earth pressure theory..The study highlights that various combination and pattern of stone column has been analysed. The influence of different numerous parameters such as diameter, spacing, length, stiffness, area ratio, length to diameter ratio etc. are also used to checked using various methods, such as experimental method, numerical analysis, FEM method (i.e. Plaxis 2D, Plaxis 3D etc.), analytical method using equation. There have been number of valuable investigation carried out on stone column with encasement of geosynthetic material like geogrid and compare that results of encased pile with the stone column of without encasement, and some study carried with experimental and FEM or numerical method and validate their results. The study also touches upon the effect of earthquake on stone column as well as on subsurface variation.

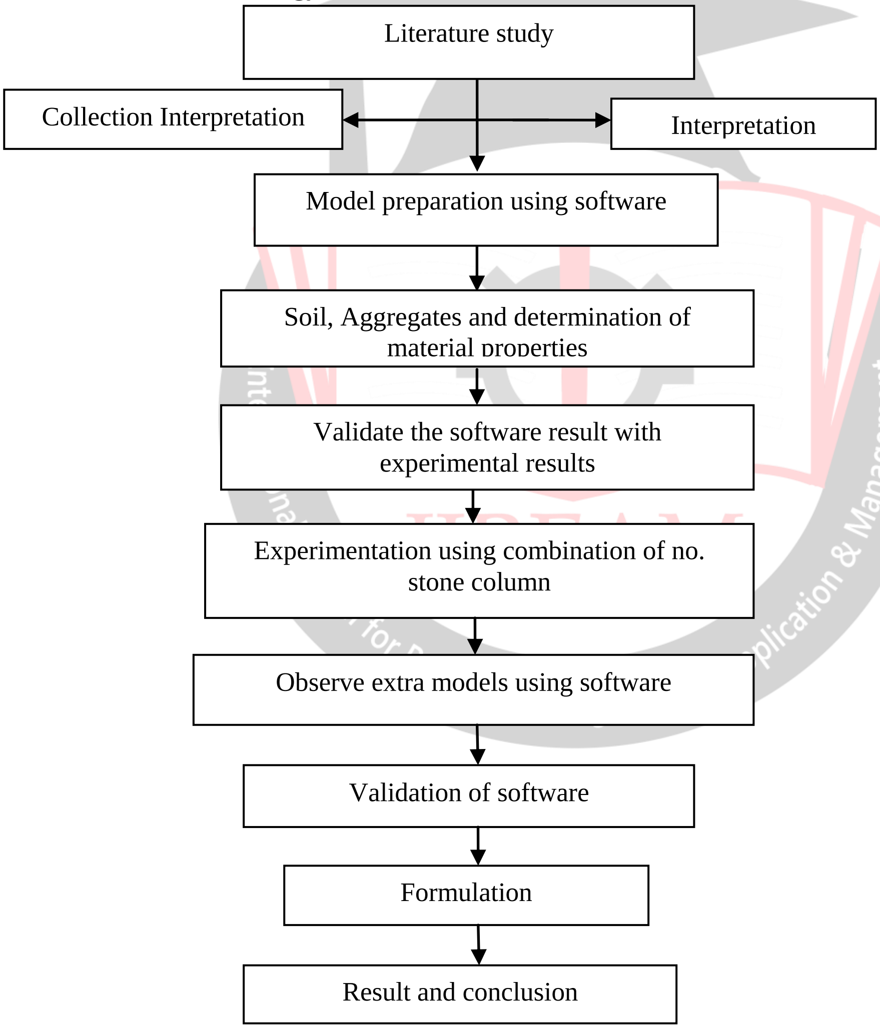
2.2 Research Gap

There have been number of valuable studies carried out on stone column by varying its parameter using various combination of methods i.e. experimental results are validate with FEM results, to check the bearing capacity and settlement of soil without granular columns or with granular columns. Numerous researchers have carried out numerical analysis on reinforced stone column as well as the analytical analysis also used for this work.
Now from this study, the lack in research found, the experimental analysis for check of bearing capacity and settlement will be check by MIDAS software with the combination of single stone column and group of stone column with the validation of results by using MIDAS GT NX software.

3. METHODOLOGY

This methodology focuses on the study of various methods that have been used so far to evaluate and observe the behaviour of stone column .The change in behaviour of granular piles under variation of parameters such as depth, length of pile, diameter, stiffness, area ratio etc. has been evaluated experimentally, numerically as well as analytically which has been described in this chapter of seminar. Now the evaluation will be conducted on FEM method. In Previous chapter the detail literature review is described, in this chapter the methodology of the work is describe.

3.1 Flow Chart of Methodology:



4. VALIDATION OF MIDAS GTS NX

Validation of the MIDAS GTS NX is based on Finite element modeling on the group of stone column using FLAC 3D as shown below:

Material Properties of the subsoil and stone column:

Table 4.1 Geotechnical parameters of the stone columns reinforced Foundation described by the Mohr–Coulomb model:

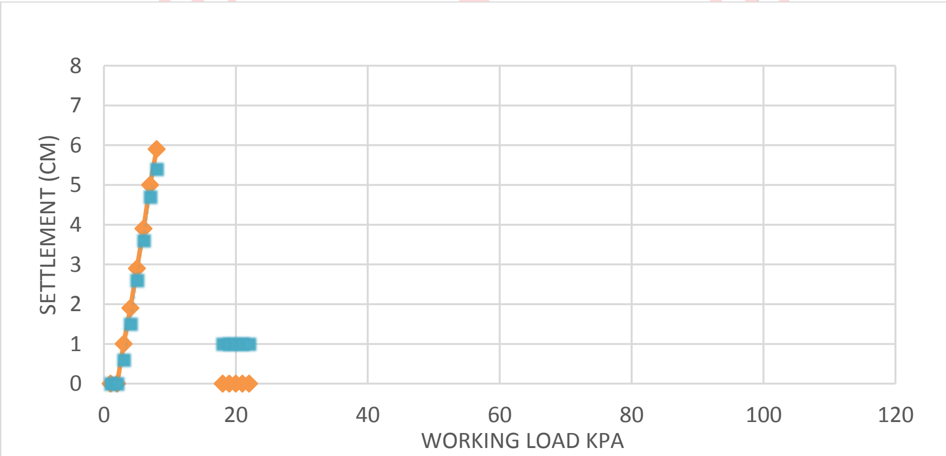
Parameter	Unit	Soft soil	Stone column
Unit wt.	kN/m3	17	18
U	Degree	0	42
C	Kpa	25	0
E	Kpa	3600	36,000
V	-	0.33	0.33
G	MPa	1.35	13.53
K	MPa	3.53	35.29
Dc	M	-	1.2

5. Further work

1) Firstly finding out the results of stone column setup using MIDAS software.
2) Make the Experimental model as per the problem statement.
3) Validation of result of both the methods, software results as well as experimental results.
4) Using validated result find out the graphs, i.e. relation of bearing capacity Vs parameters. And in the final study, analyses the whole result and make formulation and develop the equation.

6. Conclusion and Result

Based on above research work it is concluded that: 1) In this study, the three numerical modeling were implemented by FLAC 3D software: unit cell model (UCM), group of stone column (GSC).
2) And it is concluded that increasing the no. of stone column by the generated 3D numerical modeling does not affect the settlement. As the no. of stone columns increases, it increases the bearing capacity of the soil.
Result comparison during analysis (Result using FLAC 3D compared with MIDAS Software)



Settlement vs Load Graph	Settlement	
Working Load	FLAC 3D (cm)	MIDAS (cm)
0	0	0
20	1	0.6
40	1.9	1.5
60	2.9	2.6
80	3.9	3.6
100	5	4.7
120	5.9	5.4

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