Performance of Soft Clay Foundation Improved Using RCA Columns

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Abstract

Improving the bearing capacity of fine clay is one of the main tasks of stone columns in this field study, three different types of stone columns made of recycled concrete aggregate were used: single, grid (2*2), and a group of eight stone columns The grid pattern (2 * 2) of the stone column is reinforced with geogrid. The results show that the use of stone columns made of recycled concrete aggregates improves the bearing capacity of soft clay soils. Compared with natural soil, the use of stone columns with a single, grid (2 * 2), and a group of eight stone columns increases the bearing capacity by 5%, 23%, and 72%, respectively. The use of stone column reinforced with geogrid improves the bearing capacity of the soil by 144% compared to the column without reinforcement

1-INTRODUCTION

Construction on soft soils is never simple because of the deposits' extreme compressibility and limited bearing capacity. One of the most adaptable and often used techniques for reducing and accelerating settlement, increasing load-bearing capacity, reducing horizontal deformations, and improving the overall stability of the embankments over soft soil deposits is the use of compacted granular columns (Poorooshasb and Meyerhof 1996; Greenwood 1970; Almeida et al. 2018) [1]-[3[Due to the absence of lateral confinement in very soft soils, typical stone columns may not be appropriate (cu 5–15 kPa) (Wehr, 2006) [4]. Recently, covering the columns in those situations with geotextiles or other geosynthetics has shown to be an effective option. (Alexiew and Raithel, 2015; Alkhorshid et al., 2019; Almeida et al., 2019; Nagula et al., 2018; Schnaid et al., 2017) [5-9].

(Tandel .et 2013) Thus, the performance of the stone column can be improved by encapsulating the stone column with Geosynthetic, which provides additional support for the column, and prevents excessive swelling and column failure. It gives a decrease in the load-bearing capacity of the end-bearing shaft, in addition to that, the radial deformation of the stone shaft decreases with the increase in the hardness of the material used for packing[10].Also, many laboratory tests were carried out on this work by packaging such as (MURUGESAN and RAJAGOPAL [11]. MURUGESAN [12], GNIEL and BOUAZZA [13], WU and HONG [14]. In terms of the effect of the critical length to diameter on the behavior of the stone column, (Miranda 2021) presented a numerical study in which it was explained that the critical length is the one that provides further lengthening of the column a small improvement and thus is not effective in building the longer column. The length of the critical column is 2.5-1.3 times The diameter of the base of the stone for the sheathed column, for the regular columns is about 1.9 - 1.1 for the regular columns[15].Because the critical length is greater than the thickness of the soft soil layer in broad, loaded regions (such as embankments), there is no practical application for the critical column length, and it is only helpful for footings or small groups of columns (Yoo, 2010)[16].Also, the magnitude of the pressures applied to the stone column decreases with the sheathed columns. Moreover, it also contradicts the increase in diameter [17]. This is also like the experiments conducted by (Murugesan and Rajagopal 2006,2007) where the results showed a similar trend in terms of decreasing pressures with increasing diameter of the stone column [18-20]. Parametric studies of stability reduction and the effectiveness of the shaft casing is shown by the stress concentration and merging time, which are primarily controlled by the casing hardness in relation to the soil. Although columns with lower diameters are better contained, column encapsulation is still effective for joint area replacement proportions. Additionally, the applied load has to It is restricted to keep the casing from exceeding the tensile strength threshold. The solution's condensed version was created under the assumption that there is a drain. The outcomes line up with the amount of Analytics.[21].Regarding the stone columns' vertical strength, it depends on the side of confinement that the surrounding earth offers. The soil can be too loose and not offer enough lateral support for the Stone column treatment to be carried out effectively. To determine if a treatment is feasible, the unaligned shear strength of the surrounding soil is typically utilized as a criterion, with a minimum in the range of 5e15 kPa. (Wehr,2006) [22]. In recent years, his geotextile casing has been successfully used to extend the use of stone pillars to Very soft soil. Apart from lateral supports, geotextiles the casing acts as a filter between clay and sand; This guarantees Effective draining and avoids sand pollution with fines. Recently, other artificial floor materials are also being used, such as geogrid Column covers (Sharma et al., 2004; Janelle and Bouazza, 2009) [23][24]. Because of its high tensile toughness, yet they can't avoid sand radioactive contamination. Ultimately, one of the primary determining aspects in the design of stone columns is the substance of the column. Of course, it has an impact on the pillars' toughness and afterward, levels the cleaned soil. Several substances exhibit stone-like friction angles Stone pillars made of column material are used to reinforce unstable soils. Numerical element Examining the stability of fine stone-reinforced clay required analysis. Plaxis 2D columns with 15-node triangular components. A study was conducted using the Mohr-Coulomb criteria model for soft soil clay and stone pillars. The calculated settlement, excessive pressure of pore water, and lateral swelling of the stone column are provided by the numerical results of the FEM. The aggregate stability and lateral bulge of clay reinforced with a crushed stone friction angle of 27.5° were found to decrease to 0.038 m and 0.00086 m, respectively, at a 40° friction angle[25].In this study, the stone columns covered with a comprehensive covering were discussed with a length of 1.5 m and a diameter of 10 cm. The examination was conducted in a field manner, and several patterns were taken (Single stone column, four columns, eight columns,)

2. MATERIALS USED:

2.1 -Silsila.

The Soft Clay utilized in this pilot research was categorized by the Uniform Soil Classification System (USCS) as (CL). Figure 1 depicts the distribution of clay particle sizes. The physical characteristics of soft clay soil are shown in Table 1.

Table 1:Physical properties of the treated soil

Property	Values
Type soil	Soft clay
L.L%	45
P.L%	23
Maximum dry unit weight (KN/m³)	19.5
C (kpa)	20
Θ	4º
E(mpa)	15
Poisons ratio	0.45
Symbol according to Unified Soil Classification System	CL

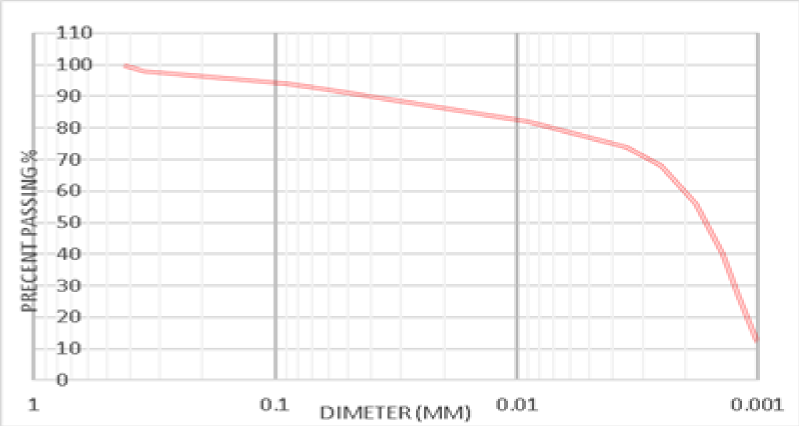

Figure 1:the distribution of clay particle sizes

2.2-Recycled concrete aggregate

Precast concrete cubes were obtained from Dhi Qar University's consulting laboratory for use in this section's laboratory testing. To guarantee a consistent gradient, they were broken up with a hammer and put through a 25 mm sieve (1-2.5 cm (See Figure 2 for recycled concrete aggregates (RCA). The physical characteristics of recycled concrete aggregates are presented in Table (2). (RCA). Table2: The characteristics of Recycled concrete aggregate

TABLE 2: The physical characteristics of recycled concrete aggregates are presented

Property	Values
Specific gravity	2.35
Total water absorption	2.40%
Moisture content	0.45%
Bulk density (Loose)	1355 kg/m³
Bulk density(compacted)	1590 kg/m³
Fineness modulus	6.23
Elongation Index	15.5%
Flakiness	5.8%
C(kpa)	0
Poisons ratio	0.35
Θ	45°

Figure 2: Recycled Concrete Aggregates (RCA)

2.3- Geogrids

High-density polyethylene HDPE net was used in this study. (Netlon CE121) was provided by the Ministry of science and technology. Table (3) illustrates the physical and mechanical properties

Table 3: the physical characteristics of the Netlon CE121.

`properties	Values
Material	High-density polyethylene
Type	CE121
Mesh aperture(mm*mm)	6*8
Weight per unit area(N/m^2)	7.15
Machine direction	9.8
Transversal direction	6.15
Machine direction	68
Transversal direction	60

3-INSTALLATIONOFTHESTONE COLUMN

The exact location of each stone column was determined and signed by the steel bar. The auger machine was used, where the auger blades were used to descend into the stone column, where drilling was done to a depth of 150 cm and a diameter of 15 cm. Circular layers with a diameter of 8-9 cm of the geogrid reinforcement were also cut to be placed inside the column. Then the strain gauge was installed on the owner surface of the reinforcement column and the circler layers. the process of affixing and installing the strain gauge on the column made of geogrid after chorally installing the geogrid reinforced down as recycled concrete aggregates (RCA) was poured inside the encased hollos in a form of 6 layers, vibrated machine was used to compact such recycled concrete aggregates (RCA) material. the mechanism for installing recycled concrete aggregates (RCA) inside the geotextile cavity using a vibrating machine strain gauge was protected as the ground surface using nylon

4-CONFIGURABLETHERECYCLED CONCRETEAGGREGATES (RCA) COLUMN

Case 1.

In this model, soft clay soil was taken in its natural form without any improvement, and a numerical examination was conducted on it in addition to the examination of precipitation and the amount of load bearing in its natural form.

Case 2.

In this case, the Recycled Concrete Aggregate (RCA) column was used to stabilize the fine clay. Table 4 shows the number of columns, their lengths and diameters, and many patterns was used for such a case as shown in Figure 3

NO. OF COLUMN	LENGTH (m)	DIAMETER (cm)
1	1.5	15
4	1.5	15
8	1.5	15

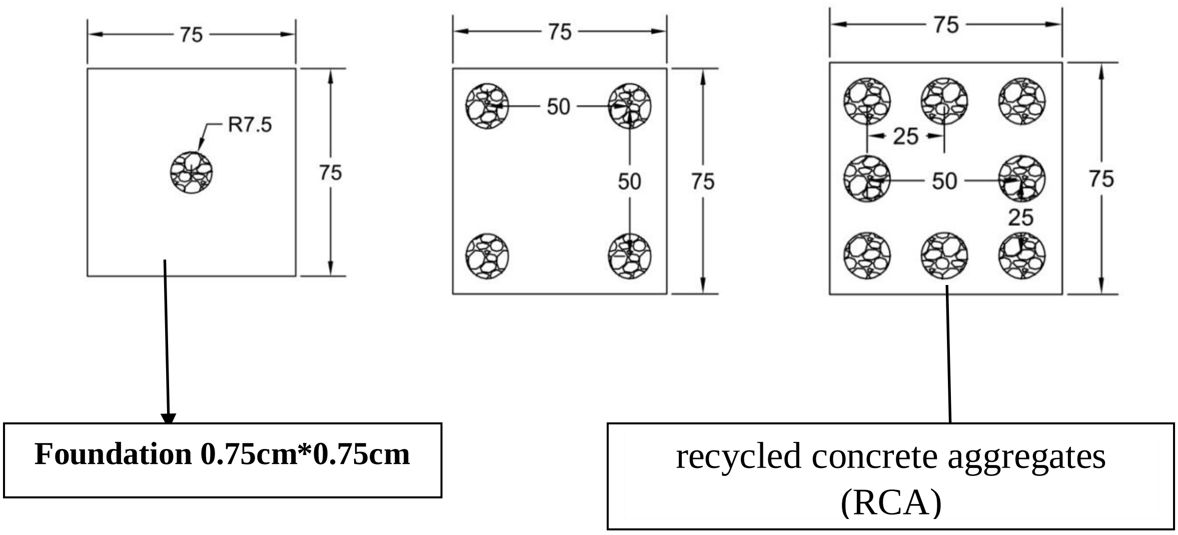

Figure 3: The seven patterns of the stone column

5. TEST PROCEDURES

The piles were reinforced with 12 mm rebar and each pile was reinforced with 5 bars. It was vertically welded with an oxygen torch so that the height was 43.5 cm. It was then stained with an antioxidant. A steel base was welded onto the concrete pillars in a circle with a thickness of 12 mm, and the entire steel structure was mounted on the pillars while adjusting the horizontality and straightness. Using two of his LVDT landing sensors on either side of a test plate secured with a side stand. The tests were performed using a plate load test, after which all sensors, sensors, and measuring devices were connected to data loggers. Outputs from load cells, displacement transducers, and strain gauges were measured and recorded using a geotechnical data acquisition system. Data is automatically transferred in real-time to a PC for real-time monitoring of trial progress. Consistent with pressure transducers, linear LDT transducers, LVDT tuning transducers, and potentiometric displacement transducers. The dirt was placed in a layer of 10 cm under the base of the area, up to 64 separate channels, and a steel foundation with dimensions of 75*75 cm and a thickness of 25 mm was employed. Figure 4 depicts the field techniques used during the examination process.

Figure 4: The field procedures for the examination process

6- RESULTS

6.1- Soil test normal (soft clay)

Figure (5). It shows the relationship between pressure and settlement of untreated soft clay soil with stone columns, where the value of the ultimate bearing capacity was extracted from the double tangent method. It was found that the BCR value is about 90 kpa, corresponding to a settlement of 29.5 mm.

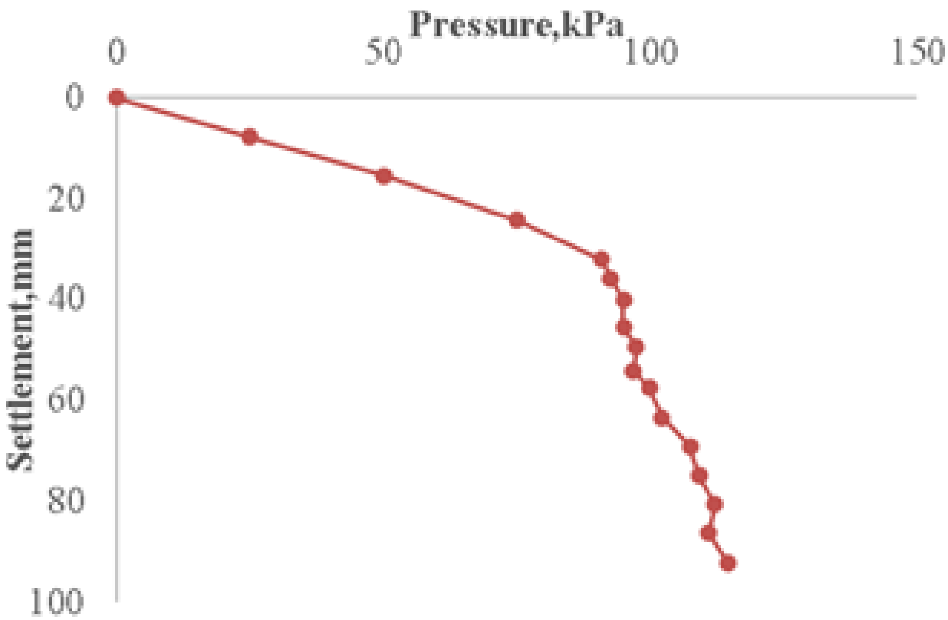

Figure 5: The relationship between pressure and settlement for untreated soft clay soils

6.2-Unreinforced recycled concrete aggregates (RCA) columns

In this investigation, the results of stone columns made of recycled concrete aggregates (RCA) without geotextile coating are presented. This field study was conducted on a single stone column without packaging that was installed inside a bed of soft clay, and it was examined after 24 hours of the preparation process. From Figure 6, which shows the relationship between the pressure applied and settlement, we notice an increase in the total carrying capacity due to the greater efficiency of the soil treated with a stone column One, an increase in the applied load is observed. This behavior is due to the correct use of the stone shaft to improve weak soils as well as the replacement area ratio and the increase in friction thanks to the stone used for the high friction angle and the double tangent method to extract the final bearing capacity. The soil treated with one stone column reached (95 kPa), with a decrease in the stability value of about (29 mm.) Where the percentage of soil improvement with one stone column was (1.14).

In this pattern, stone columns were installed in the form of a 2 * 2 grid in a square shape, with center-to-center dimensions of 50 cm. The pressure-bearing was calculated using the double tangent method, where we notice a noticeable increase in the increase in pressure tolerance and the maximum bearing value reached 111 kpa, corresponding to a settlement of 37 mm and a noticeable increase for untreated soil. The explanation for this is due to the increase in the number of columns under the square foundation and an increase in the stress distribution area on the columns and reduce the camel on the weak soil, where the percentage of improvement was found to be 1.37.

To investigate soil behavior during improvement, eight stone columns were constructed. We see a greater improvement as the number of stone columns increases. The reason is that the pressure-bearing surface has increased, the column gives the soil a lot of firmness and enhances its qualities, and the material used to make the stone columns is harder and has a higher hardness. The soil's carrying capability was determined to be 155 kPa.

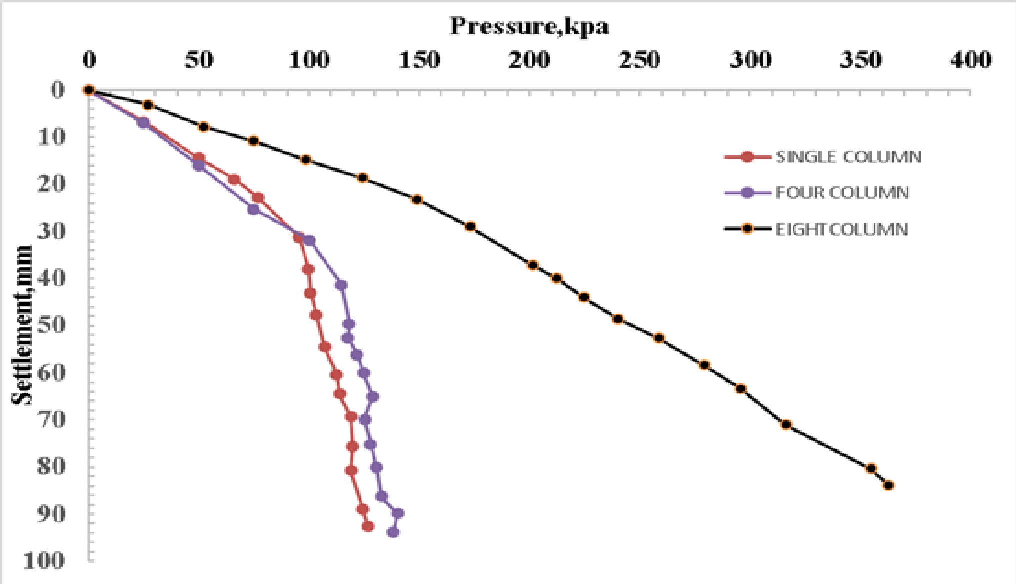

Figure 6: The relationship between applied stress and settlement of unreinforced masonry columns

The percentage improvement achieved by the stone columns is represented by the relationship. Table 45 shows the bearing capacity ratio (BCR) values

$$\mathbf{BCR}=\frac{\textbf{bearing capacity of reinforced soil}}{\textbf{bearing capacity of unreinforced soil}}$$

Table 5: The bearing capacity ratio (BCR) values

Number of stone columns	Bearing capacity ration BCR %
1	1.14
4	1.37
8	1.72

6.3-Reinforced recycled concrete aggregates (RCA) columns

This model was converted to the quadrilateral pattern using a geogrid in an integrated annular shape and suitable for the results as shown in Figure 7

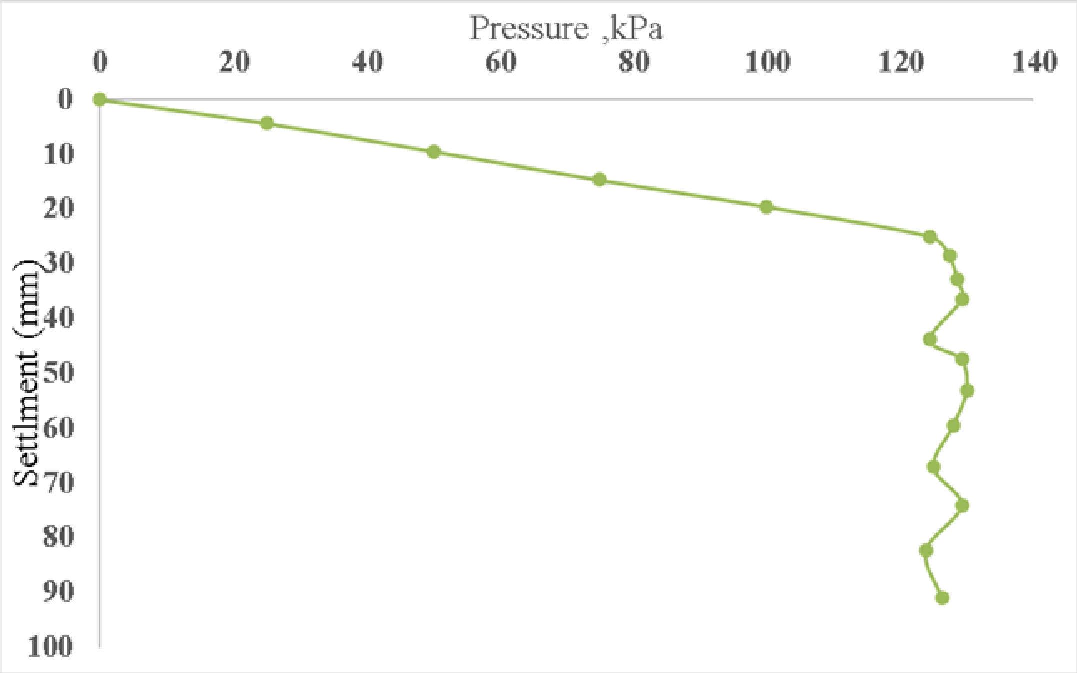

Figure 7: The quadrilateral pattern using a geogrid

In this style, laminated stone columns are installed in the form of a 2*2 square grid, with center-to-center dimensions of 50cm. We notice from the results that the casing works to improve the transfer of the load to the depths of the deep soil. The casing also works to prevent contamination of the stones that make up the column, and this will lead to a better performance of the stone pillar in the long run because the frictional properties of the recycled aggregate remain unchanged. Moreover, the casing reduces significantly due to the confinement provided by the geogrid cover, therefore, improving the performance of the stone column by reducing stability and preventing failure in the stone column. All these reasons are sufficient to increase the absorptive capacity of the soil improved by the coated stone columns, as it reached 125 kpa, corresponding to a drop in settlement, which reached 27.5 mm, where we notice a noticeable improvement When compared with the untreated soil, in addition to that, the improvement rate was found to be 1.47.

7- CONCLUSIONS

1-The use of Recycled Concrete Aggregates (RCA) is economical

2- Using stone columns composed of recycled concrete aggregates (RCA) improved weak soils effectively.

3- Unlike traditional stone columns, the pressure settlement response of geosynthetic-encased stone columns often exhibits linear behavior without showing any catastrophic breakdown. Depending on the stiffness of the geosynthetic utilized for encasement, the geosynthetic encasement enhances the load capacity.

4- The rigidity of the geosynthetic utilized for the encasement also affects how well the stone column performs.

5- Using geotextile and geogrid as the stone column, encasing the granular blanket reinforcement increases its efficacy. increases the reinforced soil and stone column's rigidity. Due to the soil particles being caught in the stiff, tensile geogrid apertures, considerable frictional strengths are generated at the geogrid-soil interface. Additionally, geotextile increases bearing capacity by preventing the stone column components from sinking into the loose soil.

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