International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 02 | Feb 2021 www.irjet.net p-ISSN: 2395-0072

PERFORMANCE OF STONE COLUMN BY USING SHREDDED TYRE CHIPS AS AGGREGATE

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Abstract - *Stone Column is a technique for improving and stabilising weak soils such as soft clays, silts, and loose sands, allowing highway facilities, storage tanks, embankments, and bridge abutments to be built. We are utilising shredded tyre scrap as an alternative material for stone aggregate in the construction of stone columns to save expenditure by partially replacing stone aggregate with shredded tyre chips. We're mixing 10 mm tyre chips and stone aggregate, which have been passed through a 12.5 mm IS sieve and are being retained on a 10 mm IS sieve. Different mix proportions of stone and tyre chips for stone column samples represented as (X% Tyre + Y% Stone) were tested such as (10%T+90%S), (20%T+80%S), (30%T+70%S), (40%T+60%S) and (100%S). Intermediate Plastic Clayey soil (CI) at OMC was used as the test sample in which stone column was installed. The CBR test was performed on the stone column with a diameter of 50 mm and depth of 100 mm installed in the compacted soil in CBR mould to determine CBR value and bearing capacity of samples. After that the results were compared with 100% stone aggregate stone column sample (100%S).*

Key Words: Stone column, CBR, Tyre chips, Stone Aggregates

1.INTRODUCTION

Soil stabilization is compulsory for the improvement of properties of soil for fulfillment of the desired requirements. Stone Column is a technique used to improve and stabilize soils considered weak such as soft clays or silts and loose sands, enabling the construction of highway facilities, storage tanks, embankments, bridge abutments and so on. This technique for ground improvement is widely used in India and all over the world. It is very effective to increase the bearing capacity of the soft soil compared to other field methods by considering the cost and its effectiveness. This technique uses columns filled with a well compacted coarse-grained material, which are allocated all over in the in-situ soil. Because the columns' materials is stiffer, more permeable, and has a higher shear strength than natural soil, the soil qualities are improved: Increased bearing capacity due to increased shear strength; decreased total and differential settlements due to improved stiffness; decrease time for the settlements to occur. In this study we have partially replaced the stone aggregate with tyre chips as aggregate in stone column and analyzed the performance of stone column i.e. CBR value and bearing capacity. In preparation of different samples (100%S), (10%T+90%S), (20%T+80%S), (30%T+70%S) and (40%T+60%S) by partially replacement of stone aggregates with tyre chips in stone column. Stone column sample size was 50 mm diameter and 100 mm depth installed in compacted soil (in three layers with 56 blows per layer by 2.495 kg hammer) at optimum moisture content in CBR mould. After preparation of different samples, we have tested those samples for CBR value in CBR testing machine (in unshocked condition) in laboratory and gotten the CBR value (%). The bearing capacity of each sample is calculated by using CBR value. Also, the results were compared with stone column sample (100%S).

For the study of stone column and its performance we have referred several research papers [1] Soumya & R. Ayothiraman studied on using of shredded tyre chips as aggregates in stone column. They investigated the bearing capacity of stone columns using various stone aggregate and tyre chip combinations. i.e. (20%T+80%S), (40%T+60%S), (60%T+40%S) and compared with (100%S). they have founded that the maximum partial of waste tyre chips in stone column was 60%. The Sample size was tested on 50 mm diameter and 300mm depth stone column installed in compacted soil size 300 mm diameter and 400 mm depth. The test Load versus Settlement was performed. they have founded that the maximum efficiency of stone column was on mix proportion of (20%T+80%S).

For the determination of bearing capacity, we referred [3] Magdi, Zumrawi and Hussam studied for the Predicting Characteristics of Bearing Strength Derived from Soil Index Properties From observed soil index values, they calculated bearing strength, California Bearing Ratio (CBR), and ultimate bearing capacity. They have founded that-

The CBR and Ultimate Bearing Capacity Relationship-

$$Qu\ (kpa) = 65 * (CBR - 1.5)$$

$$Qu\ (kpa) = 113 * (CBR - 12.5).$$

These results are on the basis of unshocked condition for CBR value.

2. MATERIALS

2.1 SOIL

The soil used in this study was Intermediate plastic clayey soil (CI) which was obtained from the Barakar road side, Dhanbad.

Following are the properties of the soil:

Table 1: **Properties of soil**

Serial No	Properties	Test value
1.	Specific gravity	2.412
2.	Liquid Limit LL (%)	37.596
3.	Plastic Limit PL (%)	17.78
4.	Plasticity Index (I_p) (%)	19.818
5.	Optimum Moisture Content (%)	17.647
6.	Maximum Dry Density (kN/m^3)	18.285
7.	Unconfined Compressive Strength (UCS) (kN/m^2)	10.447
8.	Cohesion (kN/m^2)	5.287
9.	Angle of friction (degree)	
10.	Clay and silt (%)	56.54
11.	California Bearing Ratio (unsoaked) (%)	0.964

2.2 Stone Aggregates

Crushed stone aggregate with a size range of 12-100 mm is utilized in the building of stone columns. The bearing capacity of the stone column will improve due to its high compressive strength. Many properties of stone for geotechnical engineering perspective: High density, high strength, hydrophobicity, high temperature resistance, durability, and high frictional strength. That means for enhancing the stability of soil by stone column, the stone plays a large role to transfer the overburden load to friction resistance and end bearing resistance without failing the materials used in stone column. We are utilizing stone aggregate that has passed through a 12.5 mm IS filter and has been retained on a 10 mm IS sieve. And property was followed:

Specific gravity of stone aggregate	2.948

2.3 Tyre chips

In terms of geotechnical engineering, waste tyres have a number of characteristics, including low density, high strength, hydrophobicity, high temperature resistant, durability, resilience, and high frictional strength. That means scrap tyres are a valuable and viable resource; the key is figuring out the best way to use them in a variety of ways. Tyre disposal always a problematic issue in around the world. By using tyre-waste we can enhance the properties of stone column like Bearing capacity, improvement in settlement criteria, economic, eco-friendly, and so on.

In our experiment we are using 10 mm *10 mm *10 mm size of tyre rubber as alternative material of coarse aggregate in stone column. And property was followed:

Specific gravity of tyre chips	1.1

3. Experimental Procedure

Tests like Specific Gravity test (by pycnometer method) Sieve Analysis of Soil (by wet sieving), Atterberg Limit test (for plastic limit and liquid limit test), Standard Proctor test, (For OMC and MDD), Direct Shear test (for c and Φ) Unconfined Compression test and CBR Tests were performed to determine the properties of different materials. After that samples of stone column were prepared. Following steps were followed to prepare the samples:

1. Mixing of soil with water at OMC
2. Compaction of soil in CBR mould in three layers with 56 blows per layer.
3. Soil upto 100 mm depth from top was removed by using 50 mm dia PVC pipe
4. The cylindrical hole of 50 mm in diameter and 100 mm in depth was then filled with different combinations of stone aggregates and tyre chips for each sample.

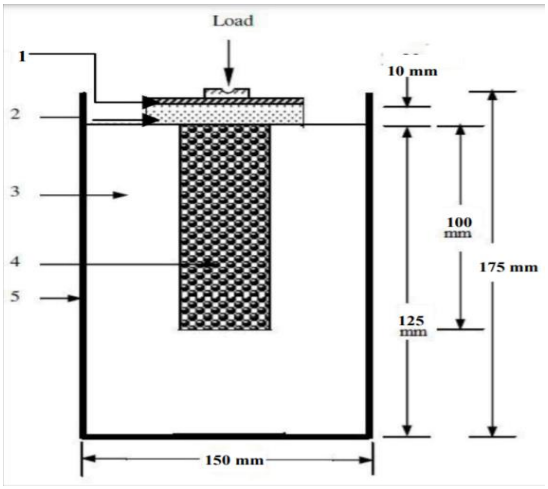

Fig 1: Representation of Sample

In Fig 1:

1 – Loading Plate
2 – Sand Bed
3 – Compacted Soil
4 – Stone Column (50 mm Dia and 100 mm depth)
5 – CBR Mould

Then each sample was subjected to CBR test and the bearing capacity was evaluated from CBR value from the relation given by M.E Magdhi [3].

Q_u (kpa) = 65 * (CBR -1.5)

Q_u (kpa) = 113 * (CBR -12.5).

Where Q_u is the Ultimate Bearing Capacity.

By changing the proportions of Stone Aggregates and Tyre Chips, the stone column represented in fig 1. The following table gives a description of the composition of various Stone Column Samples:

Table 5.1 description of samples

SL. NO.	NAME OF SAMPLE	DESCRIPTION OF SAMPLE
1	100S	100% stone aggregate
2	10T+90S	10% tyre chips and 90% stone aggregate
3	20T+80S	20% tyre chips and 80% stone aggregate
4	30T+70S	30% tyre chips and 70% stone aggregate
5	40T+60S	40% tyre chips and 60% stone aggregate

4. RESULTS AND DISCUSSION

When all samples were tested successfully, we obtained the information about performance of stone column. We represented those values in graphs and compared the results also we got load vs settlement curve for different samples.

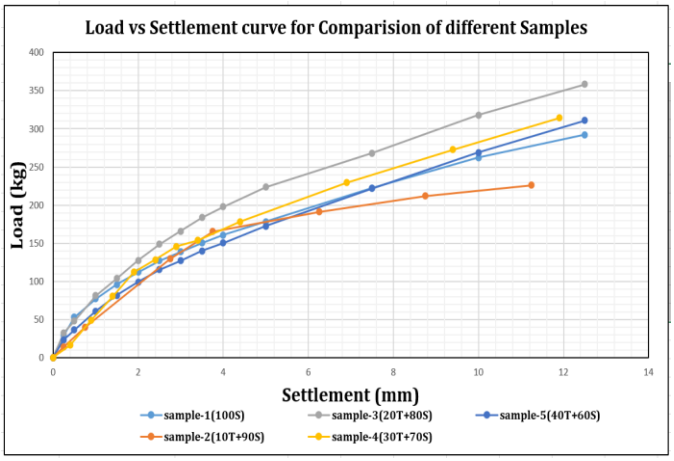

Fig 2: Load vs Settlement curves for comparison for different samples

Table 5.2 Summary of Results

SL. NO.	SAMPLES	CBR VALUE (%)	BEARING CAPACITY (KPa)	EFFICIENCY (%)
1	100S	9.268	504	100
2	10T+90S	8.673	466.245	92.509
3	20T+80S	10.88	609.70	120.97
4	30T+70S	9.609	527.085	104.58
5	40T+60S	8.41	449.15	89.117

Here efficiency is given by-

$$\text{Efficiency (\%)} = \frac{Bearing\ capacity\ of\ Sample}{Bearing\ Capacity\ of\ Sample\ 1} \times 100$$

On the basis of comparison of results, I got that sample 3 (20T+80S) has highest bearing capacity.

Representation of CBR value for comparison for different samples:

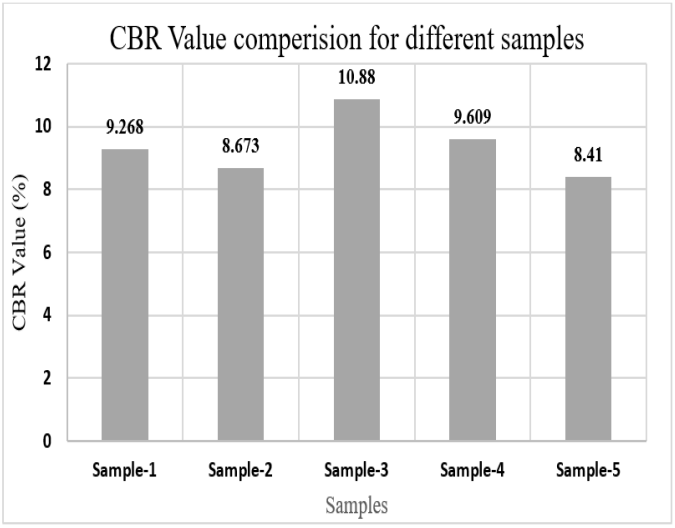

Fig 3: Bar chart comparison for different samples

5. CONCLUSIONS

After comparing all results, we concluded that

- The use of shredded tyre chips as aggregates has enhanced the performance of stone column.
- The optimum percentage of shredded tyre chips for the stone column installed in the soil

used in this study should be 20% of the total aggregates by mass.

6. FUTURE SCOPE:

- Settlement analysis of stone column by using shredded tyre chips as aggregates.
- Effect of permeability of stone column when alternative material used as aggregates.
- Performance of stone column by using filler material (for ex-fine aggregate) with aggregate.
- Stability improvement of foundation for stone column.

REFERENCES

1. S. Soumya & Prof. R. Ayothiraman (2011), use of shredded tyre chips as aggregates in stone column: an experimental study.IIT Delhi, Proceedings of Indian Geotechnical Conference , December 15-17, 2011, Kochi (Paper No. L-175).
2. Adel Hanna, Mohoud Khalifa, Mohamed Abdel Rahman (2018). Experimental investigation on stone column in cohesive soil. Published in Latest Thoughts on Ground Improvement Techniques. Publisher: Springer International Publishing.
3. Magdi M. E. Zumrawi and Hussam Elnour (2016). Predicting bearing strength characteristics from soil index properties. International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 2, March-April 2016, pp. 266-277.
4. Isabela Dellalibera Piccinini & Prof. Simon Wheeler (2014), ground improvement with stone columns - methods of calculating settlement improvement factor. University of Glasgow, School of Engineering, MSc. Civil Engineering, Glasgow.
5. Azhani Zukri and Ramli Nazir (2018), sustainable materials used as stone column filler: a short review. IOP Conference Series: Materials Science and Engineering 342 012001.
6. Pradip Das, Sujit Kumar Pal (2013). A study of the behavior of stone column in local soft and loose layered soil, Vol. 18: (pp. 1777-1786). Electronic Journal of Geotechnical Engineering.
7. Shivashankar R., Dheerendra Babu M. R., Sitaram Nayak, V. Rajathkumar (2011). Experimental studies on behavior of stone columns in layered soils. Vol:29, (pp. 749–757). Geotechnical and Geological Engineering
8. Gniel J, Bouazza A., (2009), improvement of soft soils using geogrid encased stone columns, 27, (pp. 167–175). J Geotextiles Geomembrane.
9. Lee J. S., Pande G. N., (1998). Analysis of stone-column reinforced foundations. 12, (pp. 1001-1020). International Journal for Numerical and Analytical Methods in Geomechanics.
10. Ambily A. P., Gandhi S. R. (2007). Behavior of stone columns based on experimental and fem analysis, 133(4), (pp. 405–415). J. Geotech. Geoenvironmental Engineering ASCE.
11. Malarvizhi, S. N., Ilamparuthi, K. (2004). Load versus settlement of claybed stabilized with stone and reinforced stone column. 3rd Asian Reg. Conf. On Geosynt.: 322-329.
12. Black, J. A., Sivakumar, V. And Bell, A. (2011). The settlement performance of stone column foundations, Géotechnique, 61, (11): 909–922.
13. Egan, D., Scott, W. And mccabe, B. A. (2008). Installation effects of vibro replacement stone columns in soft clay. Proceedings of the 2nd International Workshop on the Geotechnics of Soft Soils, Glasgow, pp. 23-30.
14. Afshar J. N. And Ghazavi, M. (2014). A simple analytical method for calculation of bearing capacity of stone column. International journal of civil engineering, Vol. 12, No. 1, Transaction B: Geotechnical Engineering, January 2014.
15. Samuel Thanaraj. M, Freeda Christy.C, Brema.J(2019). Analysis on the performance of stone columns with different materials in soil stabilization. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-8, Issue-3S, February 2019.
16. IS 15284-part 1 (2003), design and construction for ground improvement guidelines for stone column.
17. IS:2720(Part 4):1985 Grain Size Analysis by Wet Sieving
18. IS:2720 (Part 3): 1980 Specific Gravity test of Soil using Pycnometer
19. IS:2720 (Part 5): 1985 Atterberg Limit Test for Liquid and Plastic Limits
20. IS:2720(Part 7): 1980 Standard Proctor Test
21. IS:2720(Part 10): Unconfined Compressive Strength (UCS) test
22. IS: 2720(Part 13): Direct shear test
23. IS:2720(Part 16): CBR (California Bearing Ratio) Test