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Study on the Performance of Bitumen Waste Stone Column in Soil Stabilization

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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 bituminous waste as an alternative material for coarse aggregate in the construction of stone columns to save expenditure by partially replacing coarse aggregate with bituminous waste. We're mixing bitumen waste and coarse aggregate, which have been passed through a 16 mm IS sieve and are being retained . Different mix proportions of coarse aggregate and bitumen waste for stone column samples represented as (X% aggregate + Y% bitumen waste) were tested such as (100%C), (70%C+30%B), (60%C+40%B), (50%C+50%B) and (100%B). 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% coarse aggregate stone column sample (100%C).*

Keywords: Stone column, CBR, Bitumen waste, coarse Aggregates

I. 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 coarse aggregate with bitumen waste 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%C), (70%C+30%B), (60%C+40%B), (50%C+50%B) and (100%B) by partially replacement of coarse aggregates with bitumen waste in stone column. Stone column sample size was 50 mm diameter and 100 mm depth installed in compacted soil (in three layers with 25 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%C).

For the study of stone column and its performance we have referred several research papers [1] Soumya& R. Ayothiraman studied on using of bitumen waste as aggregates in stone column. They investigated the bearing capacity of stone columns using various stone aggregate and bitumen waste combinations. i.e. (70%C+30%B), (60%C+40%B), (50%C+50%B) and compared with (100%C). they have founded that the maximum partial of bitumen waste 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 (70%C+30%B).

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.

II. MATERIALS

2.1 Soil

The soil used in this study was Intermediate plastic clayey soil (CI) which was obtained from the karandhai road side, Than javur. Following are the properties of the soil:

Table 1: Properties of soil

Serial No	Properties	Test value
1	Specific gravity	2.7
2	Liquid limit (%)	33.5
3	Plastic limit(%)	23.1
4	Plasticity index(%)	10.4
5	Free swell index(%)	15.38
6	Max UCC strength kg/mm^2	0.021
7	OMC(%)	18
8	CBR value	2.291

2.2 Coarse 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 coarse aggregate	2.9

2.3 Bituminous Waste

Bitumen is produced through the distillation of crude oil and also occurs naturally. Bitumen is known for its waterproofing and adhesive properties. It is composed of complex hydrocarbons and contains elements like calcium, iron, sulfur, and hydrogen. Bitumen prices are determined by the state of the global economy and the supply and demand for crude oil. Bitumen is primarily used in the construction of flexible pavements.

Specific gravity of bitumen waste	1.98

III. 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 25 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 coarse aggregates and bitumen waste for each sample.
5. Cylindrical mould of height 180mm is used as model. The diameter of cylindrical mould is 150mm. Stone column diameter used for the test is 50mm. In the mould clay is placed for a height of 150mm in which the stone column is installed at the centre. Experimental set up comprises of a Cylindrical mould filled with soft clay and stone column of 50mm diameter installed at the centre. A sand layer of 10mm thickness is placed at the top as a blanket. vertical load is applied over the stone column alone using the loading plate. The load was applied through a proving ring at a constant strain rate of 1.2mm/min.
6. Tests were conducted on a single column of diameter 50 mm for various replaced materials of the stone column like Bitumen waste on a california bearing ratio as a strain-controlled test. Fig1 shows the schematic sketch of test set up of Typical test arrangement are:

Fig 1: shows the typical test arrangement of the stone column

1. Loading plate
2. Sand pad
3. Soft clay
4. Stone column (50 mm)
5. Cylindrical 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].

- Qu (kpa) = 65 * (CBR -1.5)
- Qu (kpa) = 113 * (CBR -12.5).

Where Qu is the Ultimate Bearing Capacity.

By changing the proportions of coarse Aggregates and bitumen waste, 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

S.NO	NAME OF THE SAMPLE	DESCRIPTION OF SAMPLE
1	100C	100% Coarse aggregate
2	70C+30B	70% Coarse aggregate +30% Bitumen waste
3	60C+40B	60% Coarse aggregate +40% Bitumen waste
4	50C+50B	50% Coarse aggregate +50% Bitumen waste
5	100B	100% Bitumen waste

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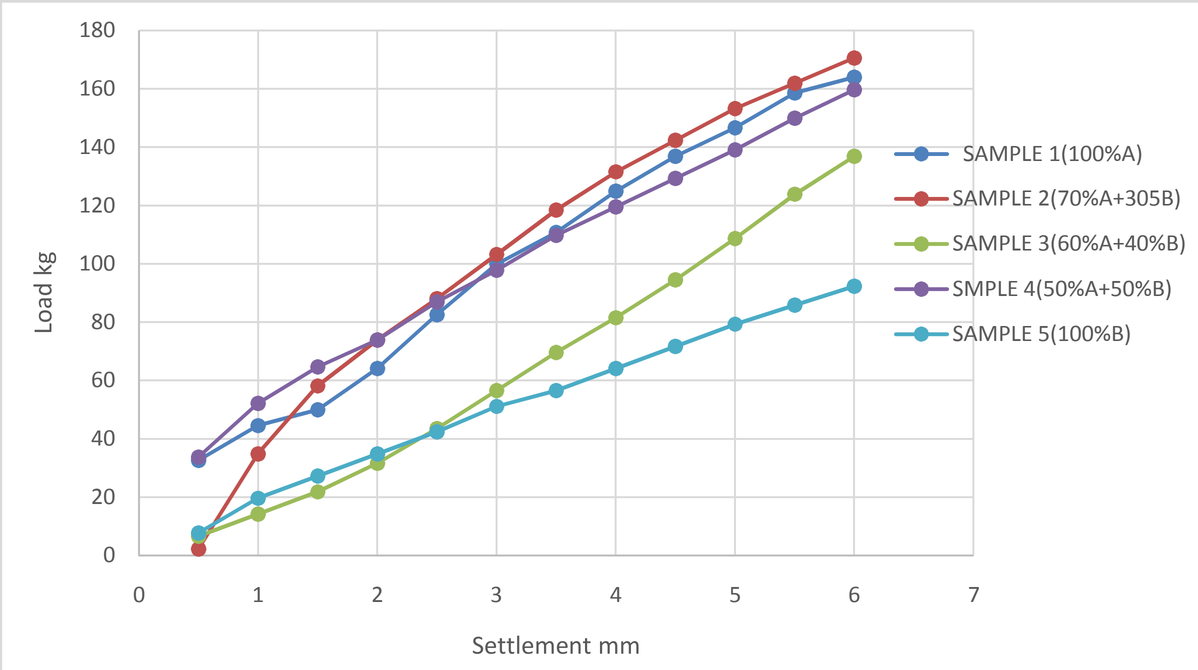
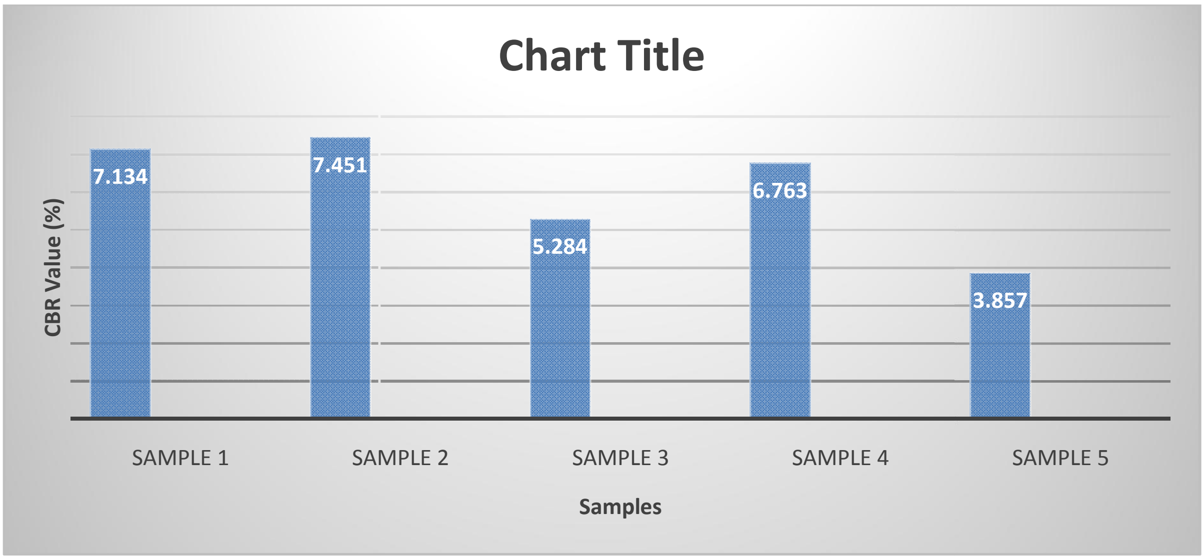
VI. RESULTS AND DISCUSSION

When all samples were tested successfully, we obtained the information about performance of stone column.



S.NO	SAMPLE	CBR VALUE(%)	BEARING CAPACITY(KPa)	EFFICENCY
1	100C	7.134	366.21	100
2	70C+30B	7.451	386.815	105.62
3	60c+40B	5.284	245.96	63.58
4	50C+50B	6.763	342.095	139.08
5	100B	3.857	153.205	44.78

Here efficiency is given by-
Efficiency (%) = Bearing Capacity of sample / Bearing Capacity of sample 1 X 100
On the basis of comparison of results, I got that sample 2 (70C+30B) has highest bearing capacity.



V. CONCLUSION

After comparing all results, we concluded that

- The use of as bitumen waste as aggregates has enhanced the performance of stone column.
- The optimum percentage of bitumen waste for the stone column installed in the soil used in this study should be 30% when compared with the 100% total aggregates by mass

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