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Soil Stabilization using Aggregate and Cement

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Abstract
With the growing urbanization, industrialization and population the availability of land is getting limited day by day driving civil engineers to modify the engineering properties of native problematic soils to meet the design specifications. Since soil is a heterogeneous material its properties varies widely. And as a result all types of ground/ soils are not fit for construction. This is where soil stabilization techniques come into play. Soil stabilization is a geotechnical process of treating soil in such a manner as to maintain, alter or improve its properties. Since, long ago soil is undergoing different types of stabilization techniques. This technique helps the soil to improve its load bearing capacity by adding different materials, chemicals, bio-enzymes etc. This paper mainly focuses on soil stabilization by aggregate and cement mixed in definite proportions. Cement as we know is a binding material which when mixed with soil would form a hardened mixture like concrete and when mixed with aggregate it will give more strength resulting in maximum bearing capacity. Different tests were conducted to check the liquid limit, plastic limit and other properties of the soil. Then series of UCS and CBR test was done to find the optimum quantity of cement and aggregate for maximum bearing capacity. Different percentage of cement and aggregates are taken to compare the bearing capacity with respect to the varying percentage of soil. At the end it was observed that with the increase in the percentage of aggregate and cement in the soil there is significant increase in the bearing capacity.
Keywords: *Soil Stabilization, Soil, Cement, Aggregate, Optimum Moisture Content (OMC), California Bearing Ratio (CBR), Unconfined Compressive Stress (UCS).*

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I. INTRODUCTION

With the growing population, construction is increasing rapidly. The availability of suitable ground for the construction of civil engineering structures is one of the biggest challenges for today's geotechnical engineers. Therefore, the engineers had to find an alternative, as construction cannot be carried out on any kind of soil. Soil is a natural material comprising of its properties and application as an engineering material, which at times is not sufficient for any kind of construction. So, therefore, to use such kind of soil it's necessary to enhance the strength and other properties of the soil as per site requirement.

Soil stabilization is a method which is used for modifying the properties of soil and increasing the strength and stability of soil. It enhances shear strength, bearing capacity and durability of soil to support construction of pavements and foundations. Through stabilization, the plasticity of soil is reduces, it becomes more workable, and its compressive strength and load- bearing properties are improved. Also reducing the construction cost by making best use of a available materials. It is done by 2 methods-

a. Enhancing soil without any admixture. Ex drainage etc
b. Modifying soil with additives (mechanical stabilization) namely, cement, lime, bitumen etc.

The soil used is fine soil passing 75 micron sieve which provides cohesion and acts as filler. Present work focuses on stabilization of soil using cement and aggregate. Aggregate is added with soil with 50-50%. Ordinary Portland cement is used of 43 grade in different percentage. The basic motive of this work is to increase the strength and stability. Different tests performed such as UCS, CBR etc to check the strength.

II. MATERIALS

Soil: The soil used in this work is taken from Tatisilwai village (Ranchi) near the pond. The soil then undergoes number of tests so as to get its properties. Soil is tested to the requirements according to Indian Standard Classification System (ISCS), IS 1498:1970, table 1. The properties of the soil obtained from the test are as follows:

Table 1. Properties of soil

S NO.	PARAMETERS	VALUES
1.	Water content (%)	38.25
2.	Specific gravity	2.41
3.	Plastic limit (%)	21.72
4.	Liquid limit (%)	30
5.	Plastic index	8.28
6.	Optimum moisture content (OMC) (%)	15
7.	Maximum dry density (MDD) (g/cc)	1.79
8.	Soil classification	**CL**

Therefore, the soil obtained from the pond is fine grained low compressible clayey soil.

Cement: The cement generally used in soil stabilization is Ordinary Portland Cement. In this work the cement used is 43 Grade Ordinary Portland Cement (IS: 8112-2000). It is manufactured by grinding high quality clinker at a fineness of around 3000cm^2/gm. The cementing action is the result of the chemical reaction of cement with the silicious soil during hydration. Using cement in soil stabilization increases plastic limit and reduces liquid limit which eventually reduces plasticity index of soil.

Aggregate: The aggregate gives volume, stability, durability, strength and is compatible to provide effective soil-aggregate mixture. The aggregate used in this work is locally available. Aggregate is checked for its strength, hardness and toughness as it should be sufficiently strong to withstand the stresses developed due to the wheel loads of the traffic.

III. EXPERIMENTAL SETUP AND RESULT:

1. LIGHT COMPACTION TEST- This test is also known as standard proctor test. IS 383-1970, Table 4 is used in this experiment. Any of the 4 grades can be used. The maximum size taken in the experiment is 25mm. It is done firstly for 50% soil mixed with 50% aggregate without any additive**.**

Table 2. 50%SOIL 50%AGGREGATE

Bulk density (g/cc)	Wc (%)	Dry density (g/cc)
1.868	6.42	1.75
2.016	9.69	1.84
2.054	12.04	1.83

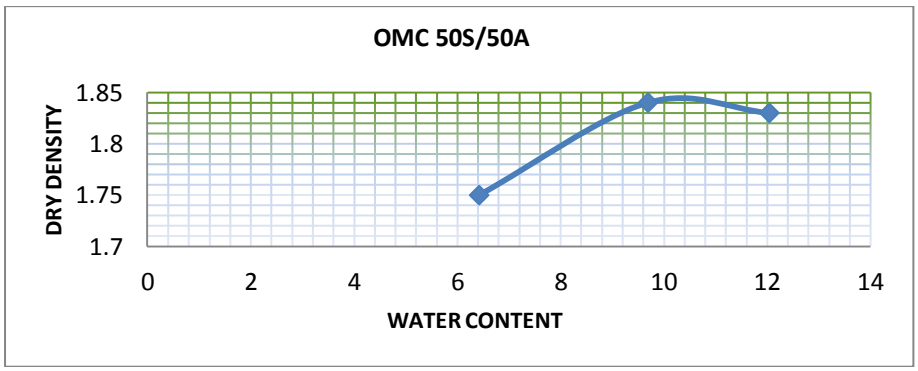

Figure 1. Graph of 50%SOIL & 50%AGGREGATE

Standard Proctor compaction test on Soil – Aggregate mixture treated with Cement

The variation of MDD with OMC with increasing doses of cement from 2% to 6 % and it is seen that the MDD increases with higher doses of cement.

Table 3. VALUES OF 2%, 4% & 6% CEMENT

2% cement			4% cement			6% cement		
Bulk Density (g/cc)	Wc (%)	Dry density (g/cc)	Bulk density (g/cc)	Wc (%)	Dry density (g/cc)	Bulk density (g/cc)	Wc (%)	Dry density (g/cc)

1.737	8.05	1.60	1.779	7.89	1.64	1.771	7.84	1.64
1.804	9.65	1.64	1.804	9.43	1.66	1.844	9.43	1.68
1.824	11.56	1.63	1.857	12.13	1.65	1.880	11.82	1.68

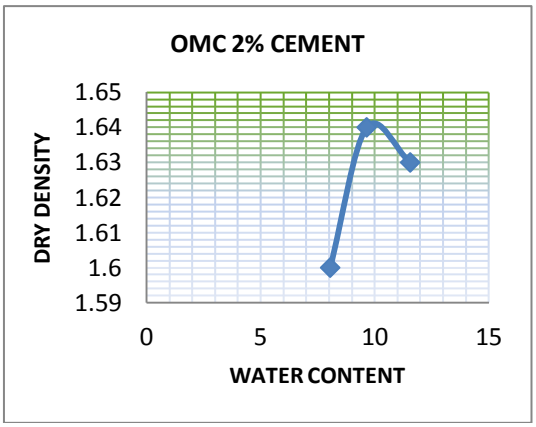

Figure 2. OMC GRAPH OF 2% CEMENT

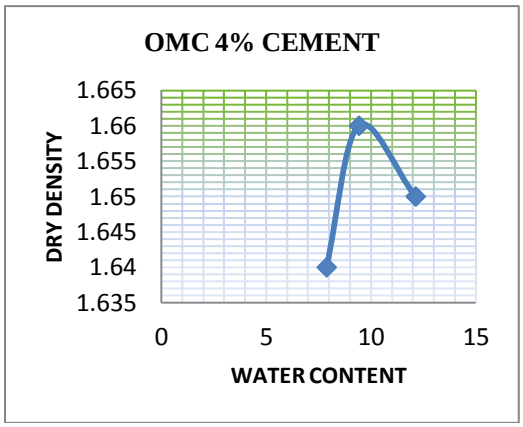

Figure 3. OMC GRAPH OF 4% CEMENT

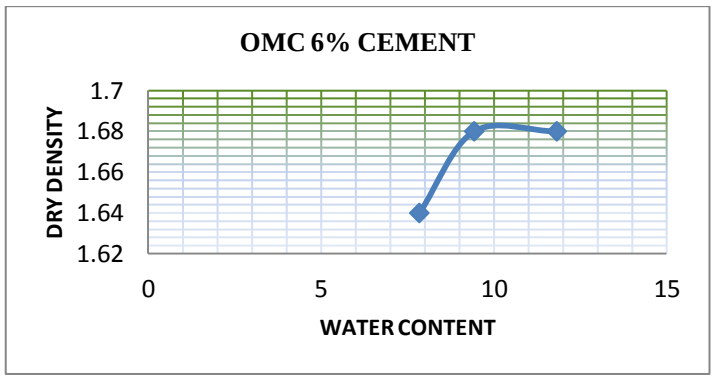

Figure 4. OMC GRAPH OF 6% CEMENT

Table 4. OMC & MDD VALUES

Material	Results	
	OMC (%)	MDD (g/cc)
Soil	15	1.79
Soil-Aggregate mixture at 50% by 50% each	10.4	1.84
Mixture with 2 % Cement	10	1.641
Mixture with 4 % Cement	9.6	1.66
Mixture with 6 % Cement	10.2	1.683

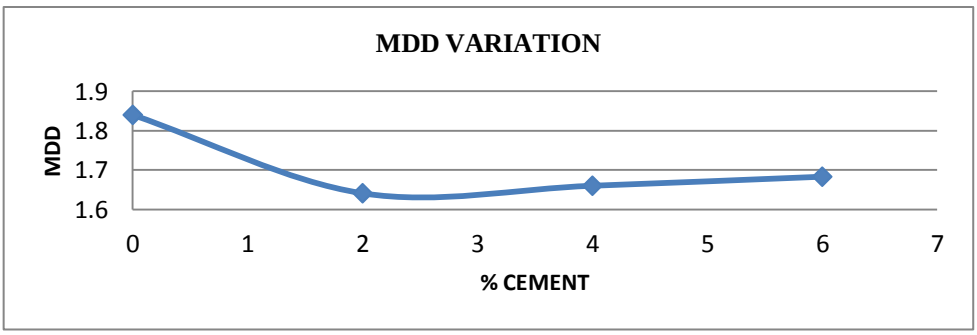

Figure 5. MDD VARIATION

The variation of OMC and MDD separately with increasing doses of cement and it can be seen that OMC decrease for initial doses of cement from 0 to 4% cement but increases for higher dose of 6% and in case of MDD there is always an increase in the value when we go for higher doses of cement.

2. CALIFORNIA BEARING TEST (CBR TEST):

CBR test is a penetration test in which evaluation of the strength of roads and pavement is done. In the present work soil and aggregate are taken constant i.e 50% soil and 50% aggregate is taken, and cement is the variable here.

CBR: Unsoaked condition in CBR test is done to check the normal field condition.

%CBR for different doses of cement for unsoaked condition:

Table 5. CBR VALUES

COMBINATION	CBR VALUE
50S/50A	23
Mix with 2% cement	19.8
Mix with 4% cement	21.6
Mix with 6% cement	25

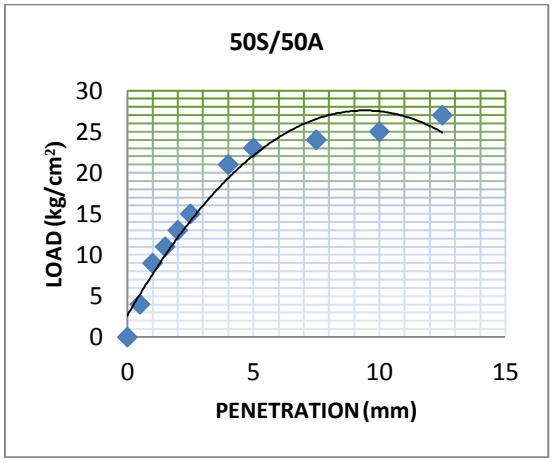

Figure 6. CBR graph 50-50% soil & aggregate

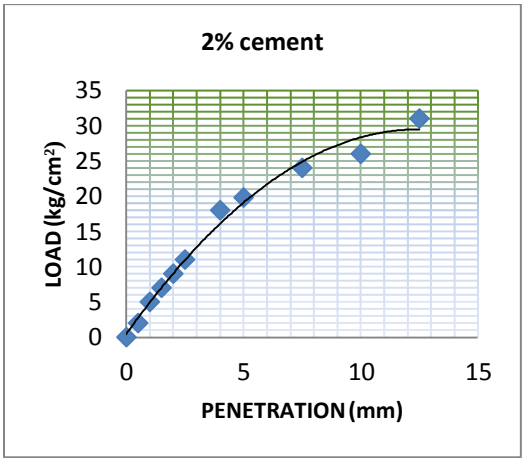

Figure 7. CBR graph for 2% cement

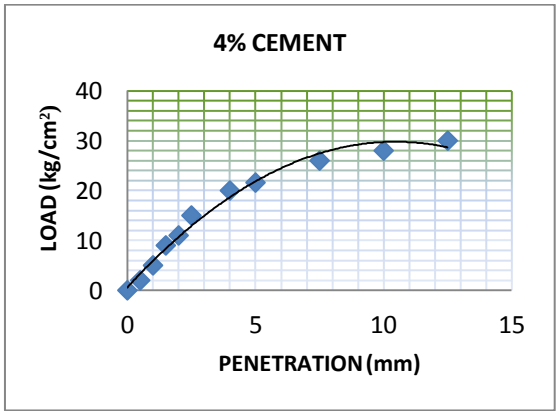

Figure 8. CBR graph for 4% cement

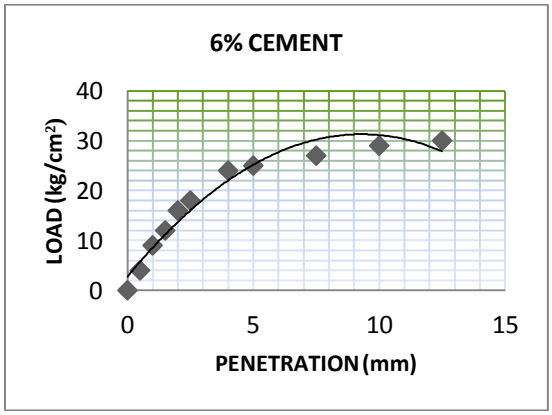

Figure 9. CBR graph for 6%cement

These values shows the variation of CBR without any cement (graph) & then after addition of doses of cement (graph). These results show that cement has a good effect in increasing the values of CBR.

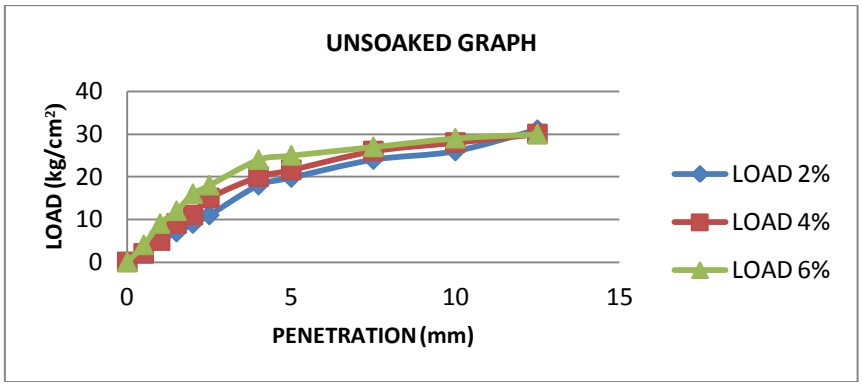

Figure 10. CBR unsoaked comparison graph

In the above graph (Fig10) we compared all the values of unsoaked CBR, which shows that CBR values increases with increase in the doses of the cement respectively.

% CBR for soaked condition:
CBR test for soaked condition is done to find the worst condition of the field.

Table 6. CBR VALUE FOR SOAKED CONDITION

COMBINATION	CBR(%)
50S/50A	10
Mix with 2% cement	10.2
Mix with 4% cement	13
Mix with 6% cement	13.61

These values shows that the addition of cement is good, but increasing the doses of cement even in small proportion is better for getting increasing CBR value.

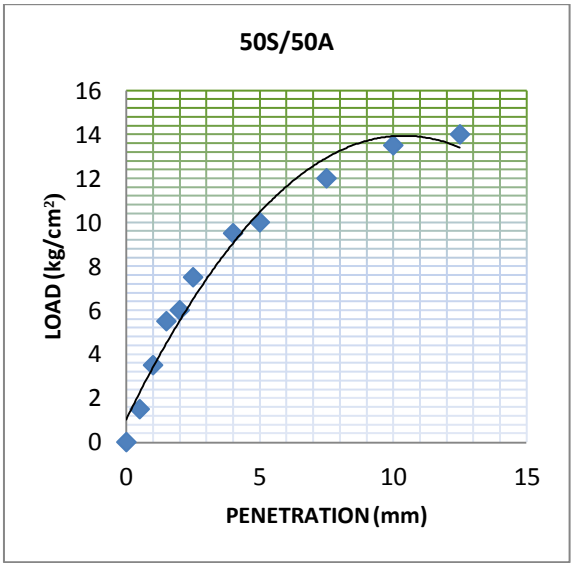

Figure 11. CBR graph for 50-50% soil & aggregate

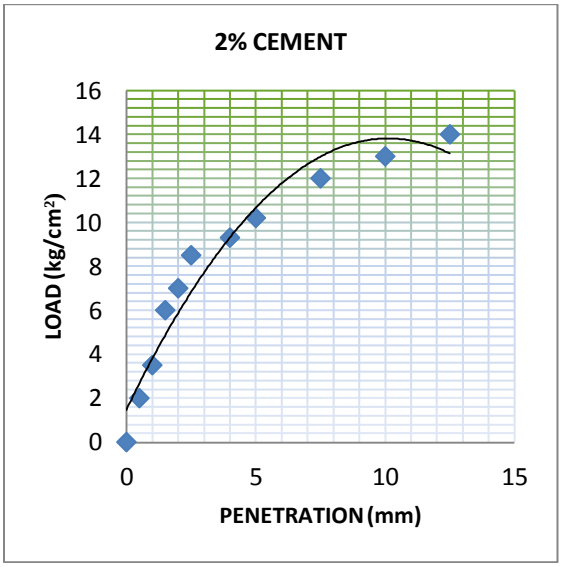

Figure 12. CBR graph for 2% cement

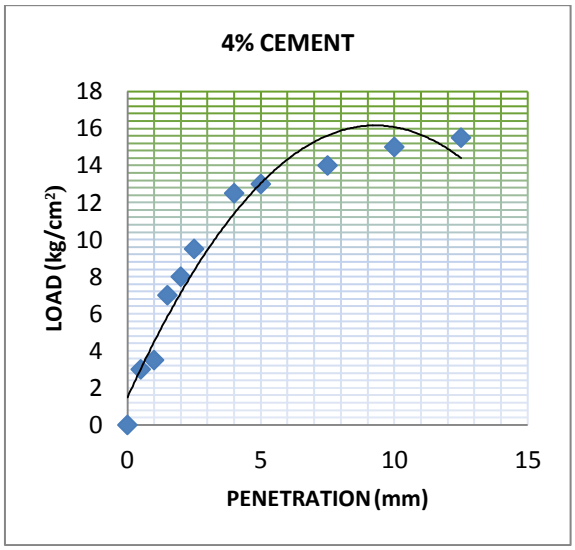

Figure 13. CBR graph for 4% cement

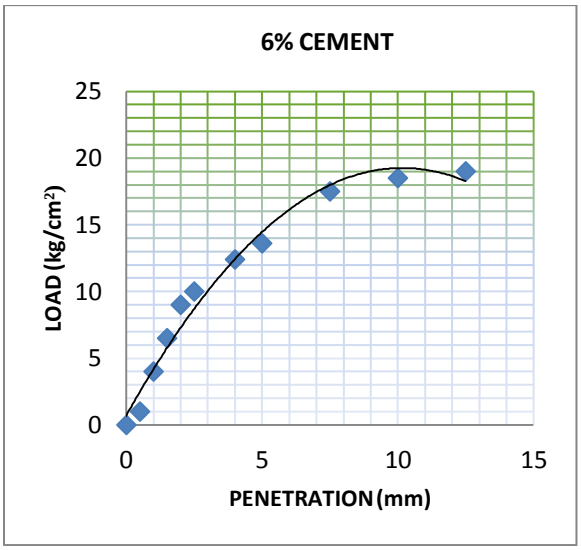

Figure 14. CBR graph for 6% cement

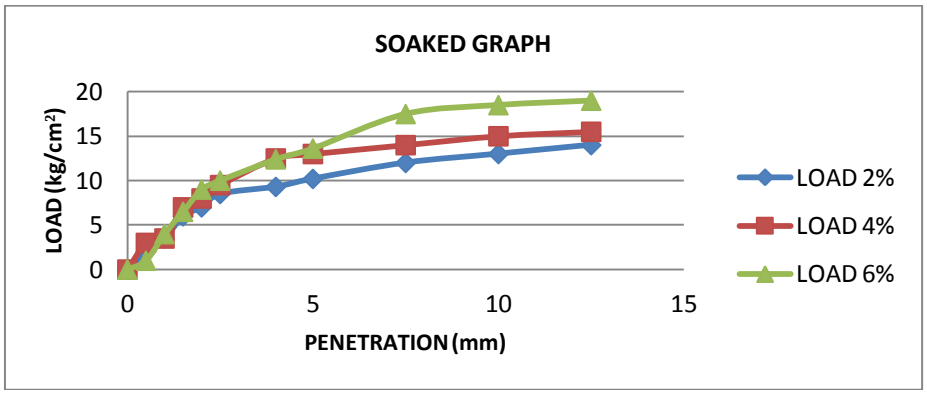

Figure 15. CBR soaked comparison graph

In this fig 15 we compared all the values of soaked CBR, which shows that CBR values increases with increase in the doses of the cement respectively.

3. UNCONFINED COMPRESSIVE TEST (UCS TEST):

It is a laboratory test use to determine Unconfined Compressive Strength of given specimen. It deals with the maximum axial compressive stress that a specimen can bear under zero confining stress. The soil sample is prepared following IS: 4332(Part I) -1967. Similarly, UCS Test on 50% Soil and 50% Aggregate Mixture was performed according to IS 4332:1970 (Part 5).

UCS of untreated Soil-Aggregate mixture:

Table 7. UCS value of 50% soil & 50% Aggregate

	Combination	Weight(g)	Volume(cc)	Density(g/cc)	Load(KN)	UCS(Mpa)
Set 1	50S/50A	6250	3370	1.85	20	0.934
Set 2	50S/50A	6323	3370	1.87	22	0.978
Set 3	50S/50A	6438	3370	1.91	24	1.067
Average = 0.993 Mpa						

UCS value for different doses of cement:

Table 8. UCS for different doses of cement

S. No.	**UCS(Mpa)**				**Average**
	% Cement used	**0 Day**	**7 Days**	**14 Days**	
1.	Soil + 0% cement	0.934	0.978	1.067	0.993
2.	Soil + 2% cement	1.118	1.235	1.382	1.245

3.	Soil + 4% cement	1.251	1.385	1.588	1.408
4.	Soil + 6% cement	1.319	1.434	1.654	1.469

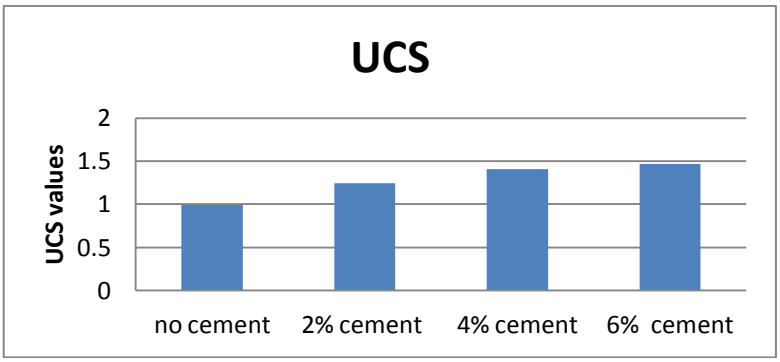

Figure 16. UCS VALUE

When different proportions of cement were added to Soil-aggregate, the result showed that with increasing doses of cement the value of UCS also increases.(fig16)

IV. CONCLUSIONS

From the work carried out, the following conclusions are made:

- Cement as a additive material in soil-aggregate mixture decreases OMC for 2 and 4 percent doses while it increases for 6 % dose of cement.
- In the case of MDD, it increases with the increasing doses of cement.
- With addition of aggregate to the soil, the CBR value of the soil increases.
- The CBR values also increases for both soaked and unsoaked conditions with increasing percentage of aggregates.
- The strength of stabilize soil increases with storage. Therefore, here UCS value for soil-aggregate mixture also increases with the increasing curing period as well as increasing doses of cement. And since it is maximum for 6% dose, therefore it is considered as optimum dose.

Hence, Soil-aggregate mix with cement as a additive provides strength and durability which is outstanding value as a base/sub-base material.

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