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Experimental Evaluation of Properties of Expansive Soil Using the Mixture of Waste Materials

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ABSTRACT
All structures rest on the ground and hence the properties of the soil will influence how the structure reacts to it. For better stability of structure such as road pavements and building foundations, the supporting soil plays an important role. To overcome the drawbacks of expansive soils, the soil can be stabilized with the mixture of waste materials like ceramic powder (WCP) and marble powder (WMP). Soil stabilization is a process by which we can improve physical properties such as its shear strength, load bearing capacity etc. In this study, it is proposed to stabilize the expansive black cotton soil using the mixture of waste materials like WCP and WMP and to evaluate the basic properties of soil such as liquid limit, plastic limit and shrinkage limit, standard Compaction test, CBR, UCS etc. The partial replacement of WCP & WMP with soil was carried out on different percentage ranging from 5% upto 30% at an interval of 5%.Thereafter a comparison was made between the natural black cotton soil and the admixed soil. From this investigation, the obtained results were satisfactory which recommends the use of proposed admixture for soil stabilization.
Keywords : Marble Waste Powder, Ceramic Waste Powder, Black Cotton Soil

I. INTRODUCTION

Soil stabilization is a process of improving the properties of soil by improving its engineering properties. Expansive soils are the soils which swell significantly when comes in contact with water and shrinks when the water squeezes out. Because of this alternate swell and shrink behavior of the soil, damages occur to different civil engineering structures founded on them. The severity of damages done by expansive soil has been well documented in literature worldwide [17, 18 and 19]. There are number of techniques available to improve the engineering properties of expansive soil to make it suitable for construction. Stabilization of expansive soil using waste materials such as WMP and WCP which has binding properties

Disposal of industrial waste is important in now days because it causes the hazardous effect on environment. Utilization of industrial waste such as WMP and WCP used in stabilization of expansive soil. In recent studies research is mostly focus on achieving enivirmental and economical advantages.

Form various literature it has been found that limited research has been carried out on the effect of waste ceramic powder and waste marble powder on different geotechnical properties of expansive soil. Therefore present study has been carried out to investigate the effect of waste ceramic powder and waste marble powder on index properties (liquid ,plastic limit and plastic index), compaction properties –optimum moisture content(OMC), and maximum dry density(MDD), unconfined compressive strength(UCS), soaked California bearing ratio (CBR) of expansive soil. . The economy of stabilization has also been studied by strengthening the subgrade of a flexible pavement.

II. MATERIALS

The materials used for this study are Black cotton soil, waste Ceramic powder (WCP) and Waste Marble powder (WMP). The properties are mentioned below.

2.1Black Cotton Soil

The expansive type of soil is in black color and also it has ability to grow cotton it is known as black cotton soil. This type of soil expand suddenly when came in contact of moisture and start swell and shrink when the moisture is removed so due to its swell- shrink behavior it is a very problematic soil for consideration of its use as a construction material.

Fig 1 : Black Cotton Soil

2.2 Waste Marble powder (WMP)

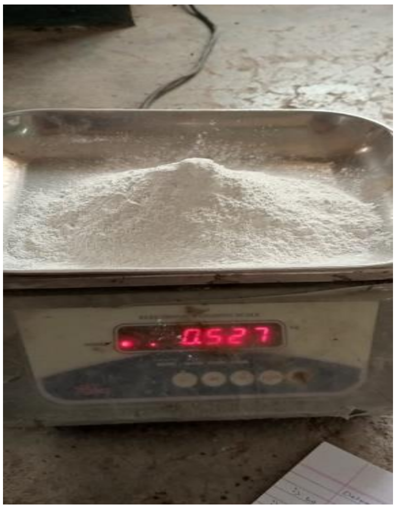

Fig 2 : Waste Marble Powder

Marble Dust is a waste product of the marble stone. This dust is produced in the process of cutting the marble stone. Marble stone is a type of metamorphic rock that is produced as a result of transformation occurred in the lime stone. In India, marble processing industry generates around 7 million tons of wastes mainly in the form of powder during sawing and polishing processes. Out the total waste generated, the state of Rajasthan alone contributes around 6 million tons of marble dust annually i.e. about 95% of the total marble dust production. This poses a huge threat to the environment and the people because most of these marble dust is dumped into the open area which causes a major environment concern. Although there are proper areas dedicated to the dumping of this waste but marble dust being a very fine powder is capable of flowing with the wind. Thus the marble dust spreads along the outer areas also and gradually settle on the plants and animals of the surroundings of the area. The spreading of marble dust in the surrounding areas certainly creates necrotic ecological condition for flora and fauna thereby changing the landscapes and habitats gradually. Thus it becomes very important to utilize huge amount of waste in a proper manner. To combact the effect of this waste material to surrounding area, it is used in various processes such as in the production of concrete as well as in stabilization of soil. Utilizing the marble dust in the process of stabilization of soil is increasing day by day due to the low cost of the material and for its ease of availability.[11]

Marble waste consist of $CaCO_3$ in range of 51 to 56% and $MgCO_3$ is upto 42 to 45 % and SiO2 is 0.5 to 2.5% and Mix Oxides 1 to 3%.

2.3 Waste Ceramic powder (WCP)

Fig 3: Waste Ceramic Powder

In the world a lot of ceramic dust is produced during production, transportation and placing of ceramic tiles.

This wastage or scrap material is inorganic material and hazardous. Hence its disposal is a problem which can be removed with the idea of utilizing it is an admixture to stabilize BC soil, so that the mix prove to be very economical and can be used as subgrade in low traffic roads or village roads.

It has been estimated that about 30% of daily production in the ceramic industry goes to be ceramic dust. The disposal of which creates environmental and economical problem. To overcome this situation this industrial waste can be used in different application, one of prime is soil stabilization.

Ceramic dust consist of high SiO_2,$Al2O_3$ and $Fe2O_3$ contents reaching up to 96%, but the amount of Fe_2O_3 and Tio_2 is 1.22%. [12]

III. SCOPE OF PRESENT STUDY

As seen from the detailed review of the literature, the major problems governing with black cotton soil are swelling, shrinkage and heaving characteristics. The black cotton soil swells when it comes in contact with water and shrinks on drying. These soils are characterized by inherent swelling and shrinkage characteristic due to presence of montmorillonite clay mineral which exhibits volume change behavior under changes of moisture content. Because of volume change in behavior this structure constructed on such soils will undergo differential settlements, cracking in buildings or total distraction of the structure, and pavements.

IV. METHODOLOGY

Stabilization can be broadly classified into two type:

- Mechanical stabilization
- Chemical stabilization

Mechanical stabilization is a process of improving properties of soil by changing the size of gradation. Generally mechanical stabilization will improve properties of soil by changing soil particle arrangement and by improving gradation of soil.

Chemical stabilization is a process of improving the soil properties of soil by using cementing agent such as GGBS, WMP and WCP. Binding agent create a cementeous reaction between with soil. Binding agents stabilize the soil and improve the properties of soil.

V. TESTS CONDUCTED

Table 1: test conducted as per respective IS code

Sieve Analysis	IS 2720 (Part 4)1965
Specific Gravity	IS 2720 (Part 3)1964
Standard proctor	IS 2720 (Part 8)1983
Liquid Limit	IS 2720 (Part 5)1985
Plastic Limit	IS 2720 (Part 5)1985
Unconfined compression test	IS 2720 (Part 10)1991
California bearing ratio	IS 2720 (Part 7)1992

5.1 Test procedures

5.1.1 Specific gravity

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc. The ratio of a given volume of a material to the equal volume of displaced liquid is defined as specific gravity. In geotechnical field specific gravity plays an important role. Specific gravity test was conducted according to IS: 2720 (Part 3): Sec 1-1980.

5.1.2 Atterberg's limits

5.1.2.1 Liquid limit

Liquid limit is the minimum water content at which soil is still in the liquid state, but has a small shearing strength against flow (liquid – plastic). Liquid limit of soil is a very important property of fine grained soil and used to classify fine grained soil. Carried out as per IS 2720 (part 5) 1985.

5.1.2.2 Plastic limit

The plastic limit is the minimum water content at which the soil particles must be able to move over one another to take up a new position and retain the new equilibrium position. The cohesion between the particles must be sufficiently high to allow the particles to maintain the moulded positions. Carried out as IS 2720 (Part 5) 1985.

5.1.2.3 Free Swelling Index Test

Expansive soils are known to have great swelling ability because of the presence of swelling dominant clay minerals such as the montmorillonite group.

5.1.3 Compaction Test

Fig 4 : SPT mould

Compaction test was conducted according to IS: 2720 (Part 7)-1980. For compaction test soil should pass through 4.75 mm sieve. For compaction test soil should pass through 4.75 mm sieve. 2500 gm of oven dried measured soil was taken for doing the compaction test. Predicted amount of water was added to the soil. The soil with admixture is placed into the compaction mould in three layers. The soil compaction mould volume was about1000cc.using hammer for each layer is compacted. For each layer compacting to 25 blows of energy was used.

5.1.4 Unconfined compression test

Fig 5 : UCS Specimen of admixed BC soil

The unconfined compression strength test is by far the most popular method of soil shear testing because it is one of the fastest and cheapest methods of measuring shear strength.

The unconfined compression test is inappropriate for dry sands or crumbly clays because the materials would fall apart without some land of lateral confinement. Carried out as per IS 2720(Part- 10)1991.

VI. RESULTS AND DISCUSSIONS

6.1 Compaction test result

Table .2 : OMC and MDD of soil at Varying % of admixed soil

Sr.no.	Standard Proctor Test	Optimum moisture Content	Maximum Dry Density	% increase in MDD w.r.t. BS
1	BC100MC00	19.918	1.642	-
2	BC95MC05	19.658	1.642	0
3	BC90MC10	16.415	1.673	1.887
4	BC85MC15	12.588	1.685	2.618
5	BC80MC20	11.697	1.736	5.724
6	MC75MC25	14.806	1.714	4.384
7	MC70MC30	18.368	1.702	3.654

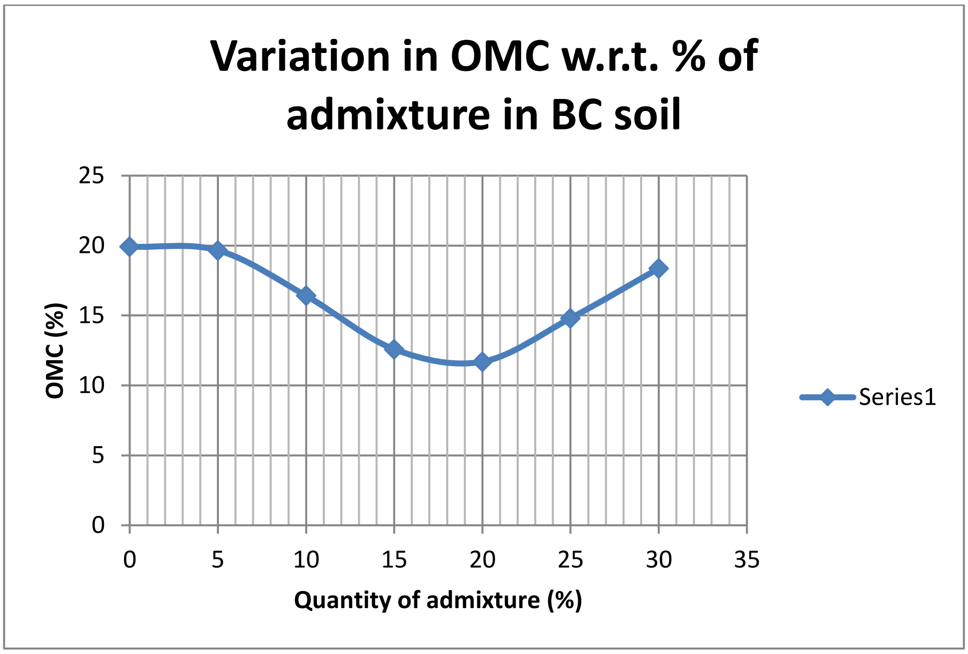

Fig 6 : Graph of OMC (%) v/s Percentage increase of admixture in BC Soil

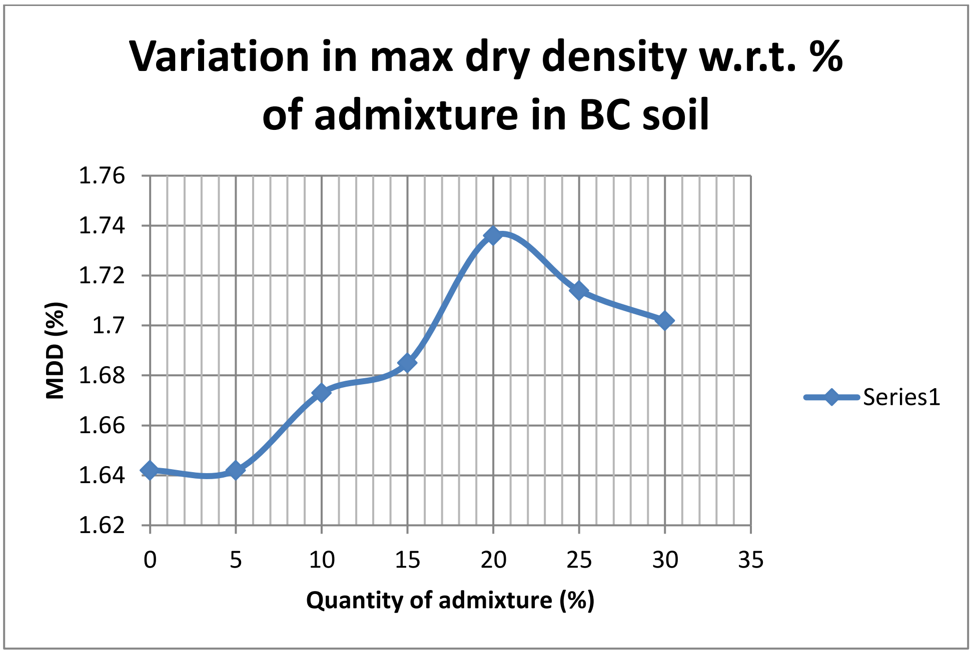

Fig 7 : Graph of MDD (%) v/s Percentage increase of admixture in BC Soil

6.2 Atterberg's Limit

6.2.1 Shrinkage Limit test

Table 3 : Variation in shrinkage limit based on admixed BC soil

Sr.no.	Shrinkage Limit test w.r.t. admixed soil	Shrinkage limit(%)
1	BC100MC0	8.2
2	BC95MC05	10.029
3	BC90MC10	10.748
4	BC85MC15	11.467
5	BC80MC20	12.186
6	BC75MC25	10.386
7	BC70MC30	8.685

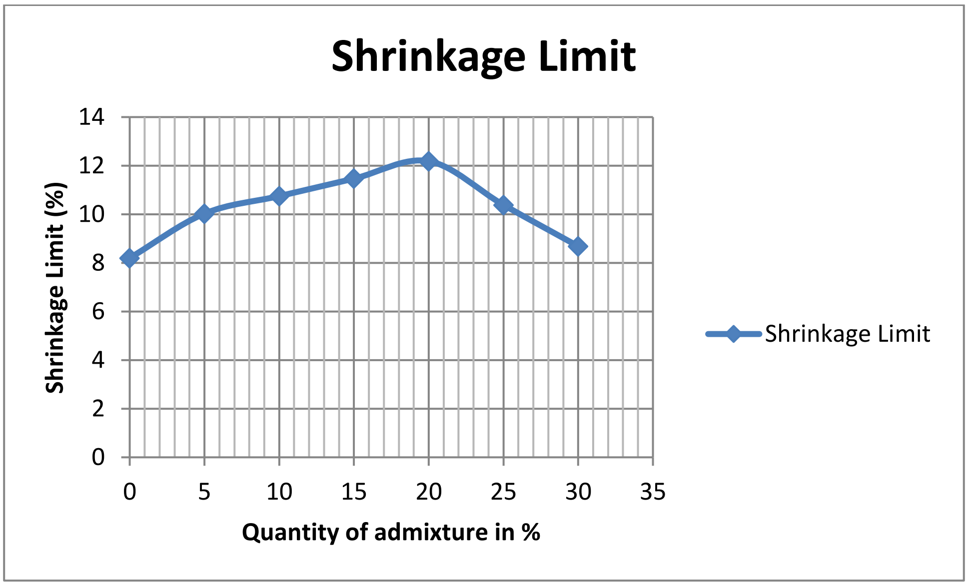

Fig 8 : Graph on Shrinkage Limit v/s Quantity of admixture

6.2.2 Plasticity index

Table 4 : Variation in plasticity index based on the admixed BC soil

Sr.no.	Test on admixed soil	Plasticity Index (%)
1	BC100MC0	41.71
2	BC95MC05	30.122
3	BC90MC10	29.354
4	BC85MC15	26.569
5	BC80MC20	23.887
6	BC75MC25	22.334
7	BC70MC30	27.189

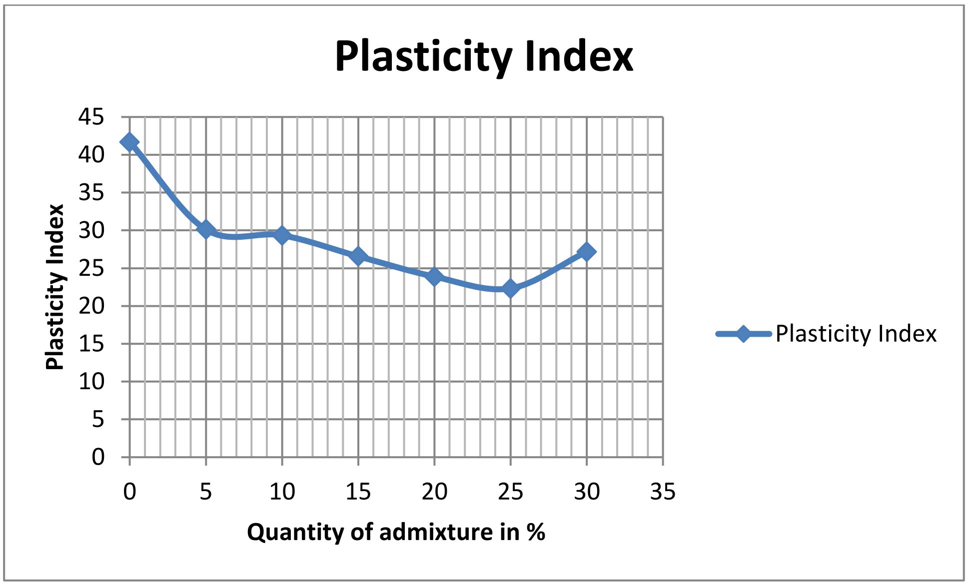

Fig 9 : Graph on plasticity Index v/s Quantity of admixture

6.2.3 Free Swell Index

Table 5: Variation in swelling Index w.r.t. admixed BC soil

Sr.no.	Free swell Index	Swelling Index	Degree of expansion
1	BC100MC0	33.33	Moderate
2	BC95MC05	27.16	Moderate
3	BC90MC10	25.53	Moderate
4	BC85MC15	20	Low
5	BC80MC20	18.26	Low
6	BC75MC25	23.68	Moderate
7	BC70MC30	25.52	Moderate

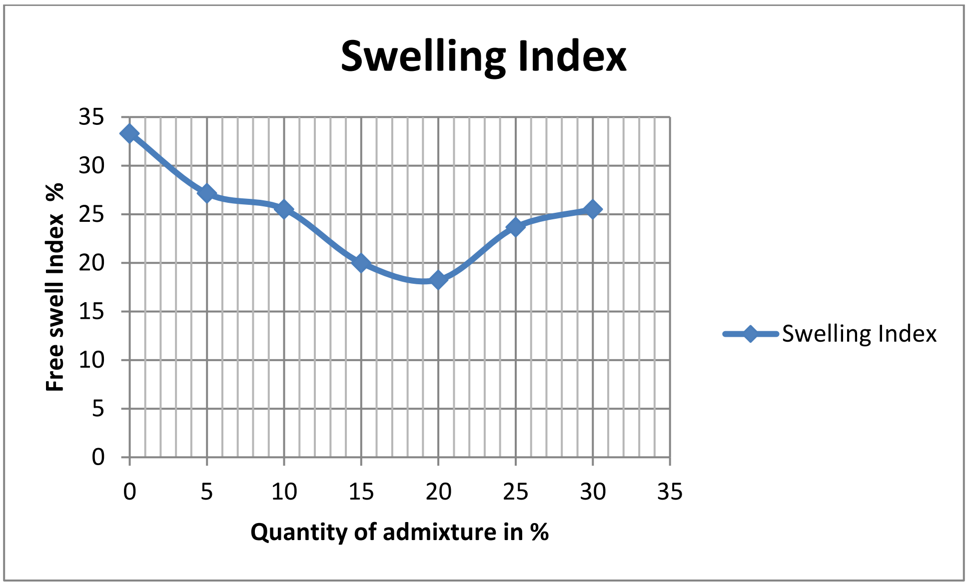

Fig 10 : Variation in swelling index w.r.t. quantity of admixture in BC soil

6.4 Unconfined Compression strength test

Table 6 : Variation in unconfined comp. strength w.r.t. admixed soil

Sr.no.	UCS test	UCS at 3days	UCS at 7days	UCS at 14days	UCS at 28days
1	BC100MC0	71.34	71.34	71.34	71.34
2	BC95MC05	101.91	104.46	107.01	108.54
3	BC90MC10	96.82	98.85	101.91	105.48
4	BC85MC15	78.98	81.53	83.06	84.08
5	BC80MC20	50.96	54.52	59.62	62.68
6	BC75MC25	43.31	47.39	48.92	54.01
7	BC70MC30	25.48	30.57	33.12	35.67

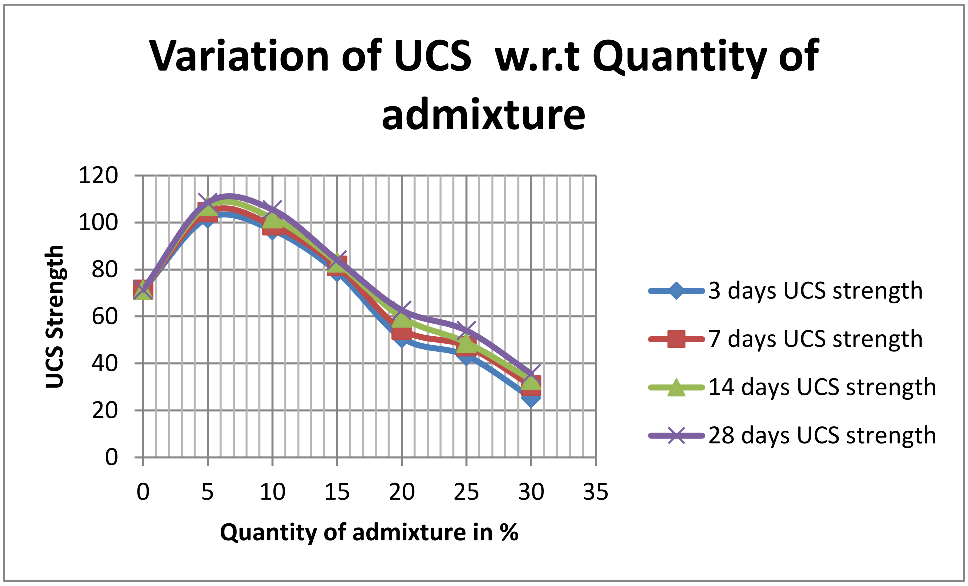

Fig 11 : Graph betn Unconfined Compressive strength vs Percentage of admixture

6.5 California Bearing Ratio Test

Table 7 : Unsoaked CBR value at varying percentage of admixture in BC soil

Sr.no.	CBR test w.r.t. admixed soil	Unsoaked CBR value (%0)
1	BC100MC0	7.15
2	BC95MC05	9.35
3	BC90MC10	12.62
4	BC85MC15	14.102
5	BC80MC20	18.585
6	BC75MC25	17.474
7	BC70MC30	14.102

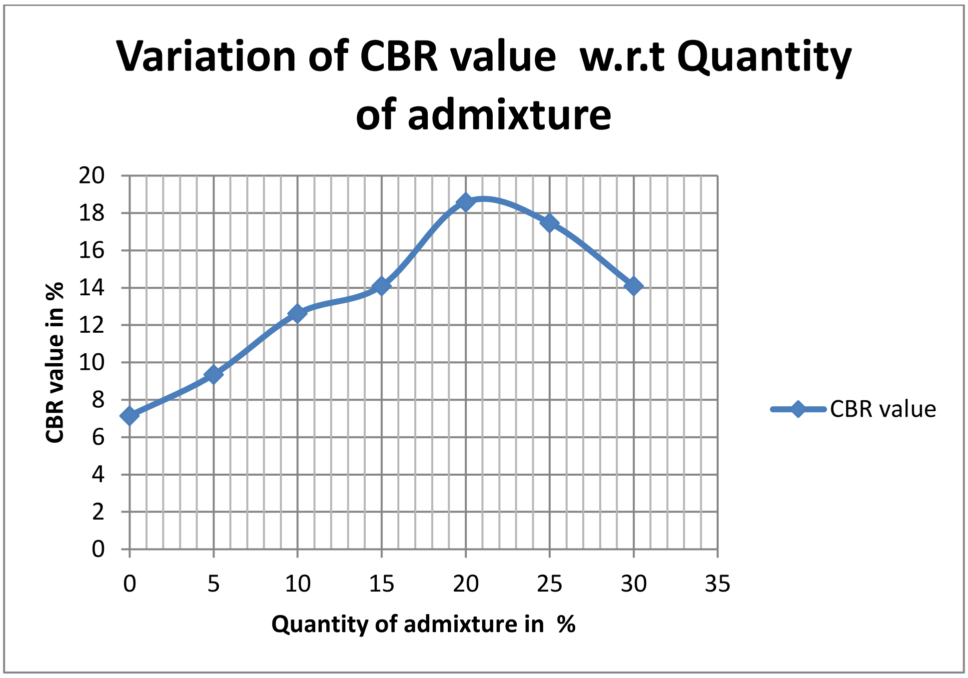

Fig 12 : Quantity of admixture in % v/s CBR value in %

VII. CONCLUSION

Based on the results, discussions and detail analysis of the data obtained from the experimental results, the following conclusions have been drawn:

- From the combination of WCP and WMP used in BC soil the Sp. Gravity was found to be nearly same for different replacement levels.
- Liquid Limit, plastic limit and plasticity index of BC soil decreased with the addition of WCP and WMP. The addition of WCP and WMP causes flocculation of clay particles and increases the number of coarser particles which helps in reducing the Atterberg limits.
- As the percentage of WCP and WMP in BC soil increases the free swell index constantly decreases upto 20% after any addition of admixture free swell index increases.
- The MDD was increased by 5.724% and the OMC of Black Cotton Soil was decreased by 40.376% for the 20% replacement level.
- The Unsoaked CBR value of admixed soil sample increased by 159% (1.5 times) w.r.t natural BC soil. It indicate that the void ratio reduces thus decreasing the permeability of soil and therefore the soil specimen gets less affected by water.
- The variation in WMP and WMP content shown maximum UCS value at the replacement level of 5%. Unconfined compressive strength of admixed soil specimen increased by 52.144% with the increase in WMP content and WCP and found maximum UCS value at proportions 5 percent of WCP+WMP in equal proportion.
- The maximum unsoaked CBR value obtain after stabilization with WCP and WMP was increase significantly as the replacement level increase upto 20%
- The maximum unsoaked UCS value obtain after stabilization with WCP and WMP was increase significantly as the replacement level increase upto 5% after significantly decreases.

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