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Evaluating Suitability of Ceramic Waste as a Stabilizer Material for Pavement Subgrade

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ABSTRACT: This paper deals with enhancing the engineering properties of weak soil by treating it with ceramic waste. Weak soil generally swell significantly when come in contact with moisture and shrink when the moisture squeezes out, and this type of soil will have low bearing capacity. Therefore it is necessary to stabilize weak soil, thus improving the load bearing capacity of a sub grade to support pavement. The weak soil is collected locally and mixed with the ceramic waste from 0 to 40% at an increment of 10%. In total 5 mixes were prepared. Liquid Limit tests, plastic limit tests, standard Proctor compaction tests, CBR tests were conducted on these mixes as per Indian Standard Codes for finding optimum percentage of tile waste material.

KEYWORDS: CBR, Subgrade, Ceramic waste, Weak soil.

I. INTRODUCTION

Clayey soils are of particular interest in agricultural, geotechnical engineering and environmental application. Clayey soils commonly develop desiccation (shrinkage) cracking which has a significant influence on the transport of moisture and solutes. Seasonal climatic changes can also cause clay soil to swell and shrink posing difficulties in engineering applications. These volume changes alter the structure of these soils leading to changes in soil behaviour. A primary feature of clay soil is that they undergo changes in bulk soil volume during wetting and drying. The amount of volume change is, in fact a reflection of the degree of structural change that is taking place. Desiccation cracks can have a paramount influence on the structure development of clay soils. Clayey soil is widely many parts of India covers about 40 percent of the total area of the country. Most of the structure constructed on the clayey soil fails due to alternate shrink swell behaviour of the soil. Fig no.1 shows the soil deposition in India,

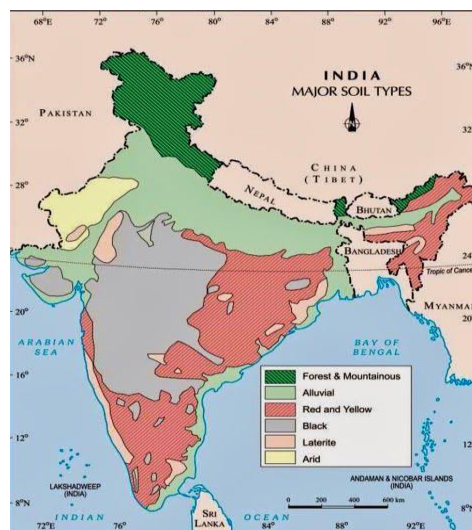


Fig.1 Soil deposition in India

The earlier ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a coloured, smooth surface. The potters used to make glazed tiles with clay; hence the tiles are called as “ceramic tiles”. The raw materials to form tile consist of clay minerals mined from the earth’s crust, natural minerals such as feldspar that are used to lower the firing temperature, and chemical additives for the shaping process. A lot of ceramic tiles wastage is produced during formation, transportation and placing of ceramic tiles. This wastage or scrap material is inorganic material and hazardous. Vitrified tiles are the latest and largest growing industry alternate for many tiling requirements across the globe with far superior properties compared to natural stones and other man made tiles. Hence its disposal is a problem which can be removed with the idea of utilizing it as an admixture to stabilization.

Muralidharan et al.(2019) studied the effect of vitrified tile powder and calcium hydroxide on the soil. The addition of vitrified tile powder and calcium hydroxide decreases the liquid limit and plastic limit of the soil upto 15% of vitrified tile powder and 10% of Ca (OH)₂ and it increases beyond this limit.**Neeladharan et al. (2017)** had studied Stabilization of Soil by using Tiles waste with Sodium Hydroxide as Binder. From that can be seen that the CBR value increases from 1.93 to 16.19% with the addition of tile waste up to 35% and sodium hydroxide up to 17.5% .

Raghudeep and Prasad (2015) had mixed the available clayey soil with vitrified polish waste (VPW) up to 10% for flexible pavement construction. At 10% mix proportion of VPW, Liquid limit and Plasticity index of the soil decreased by 17.29% and 42.77%.**Ameta and Woyal (2013)** had stabilized the dune sand using ceramic tile waste as admixture. From the test results it was found that on increment of particle size of admixture, the C.B.R. value of the mix composition increases. Also as the quantity or percentage of admixture increases, the C.B.R. value of the mix composition increases.

An ideal solution lies for reducing project cost, increasing longevity and reduce accumulation of waste shall be through utilization of industrial waste combined with weak soil for pavement construction. Few types of waste materials namely crusher dust, fly ash and tile waste are popular as admixtures in improving weak soils. From the available literature it is found that limited research has been done to study the effects of tile waste on different geotechnical properties of expansive soil. In the present study has been undertaken to investigate the effects of tile waste on index properties, compaction properties, soaked California Bearing Ratio (CBR) and swelling pressure of an expansive soil .The economy of stabilization has also been studied by strengthening the expansive soil subgrade of a flexible pavement.

II. OBJECTIVE

- To estimate the effect of ceramic waste on expansive subgrade.
- To evaluate the changes in the properties of weak subgrade due to stabilization with ceramic waste.
- To evaluate the variations in the values of CBR of expansive subgrade due to stabilization with ceramic waste.
- To determine suitability of usage of ceramic waste for the stabilization of weak subgrade.

III. MATERIAL CHARACTERIZATION

A. Weaksoil

The Expansive soil used for experiment was collected from Yavat village at about 55 km away from Pune district located in Maharashtra. The properties of clayey soil are detailed below

SR.No	Properties of soil	Values
1.	Specific gravity	2.22
2.	Liquid limit	75.59%
3.	Plastic limit	32.16%
4.	Plasticity index	43.43%
5.	Soil classification	CH Group
6.	Standard proctor test	



	Maximumdrydensity	1.38
	Optimummoisturecontent	32%
7.	CBR value(@2.5mmpenetration)	3.00%

B. Tileswaste

Ceramic Waste is collected from Rak Ceramics, Kalash Ceramics, Global Ceramics. The vitrified tile is a successful waste material in stabilization strategy which enhances the composition qualities, subgrade characteristics, Swelling characteristics, compressibility characteristics. It has a specific gravity of 2.60. The tile waste was crushed into the size range of 4.75mm to 75µm with the help of a hammer for experimental use. The Ceramic waste were crushed first manually and then mechanically to bring them to the required size. The mechanical crushing was done in Los Angeles Abrasion Machine.

IV. METHODOLOGY

The soil used for the experimental work is collected from selected area. The soil is oven dried and then it is sieved through respective sieve sizes(425µ,90µ,4.75mm) for the corresponding test. The ceramic waste were broken into powder form manually and then mechanically by using Los Angeles Abrasion Machine. The ceramic waste is mixed with corresponding soil sample at different proportions. The soil is mixed with the ceramic wasteto make a homogenous mix.and then the sample is used for the experimental works.

V. EXPERIMENTAL WORK

5.1 INDEX PROPERTIES

Liquid limit and plastic limit of the Expansive soil was obtained by treating it with different percentage of ceramics waste. The test were conducted on the soil sample according to IS 2720(part5)1985.

Table.1 Determination of plasticity index of sample on replacement of ceramics waste

% of tile waste	Liquidlimit	Plastic limit	Plasticity index(IS1498:1970)
0%	75.59	32.16	43.43
10%	68.60	28.75	39.85
20%	66.16	27.41	38.75
30%	62.97	26.50	36.47
40%	68.68	21.04	47.64

The table 1 shows the value of liquid limit and plastic limit with varying percentage of ceramic waste. From the table, it can be evaluated with the addition of ceramic waste up to20% the liquid and plastic limit decreases beyond this limit the value increases.

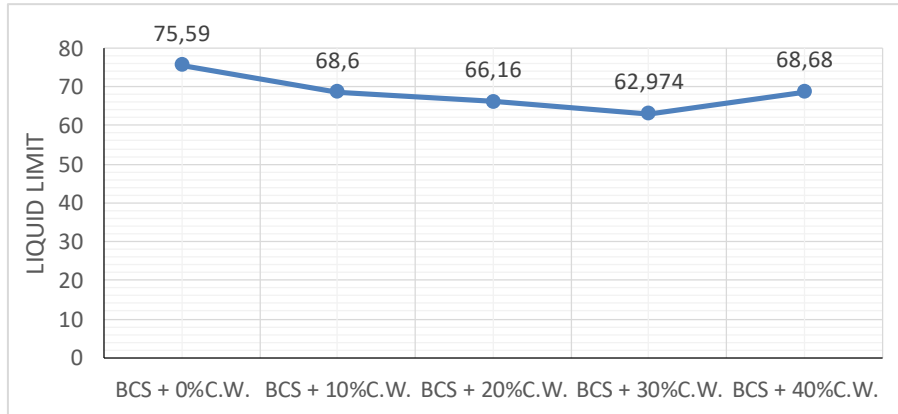


Fig.2 Liquid limit result with varying percentage of ceramic waste

The obtained result of liquid limit treated with different percentage of ceramic waste as shown fig.2. From the fig it can be noted that with the increase in percentage of tiles waste the liquid limit of soil decreases from 75.59% to 66.16% and slightly increases on addition of 40% ceramic waste.

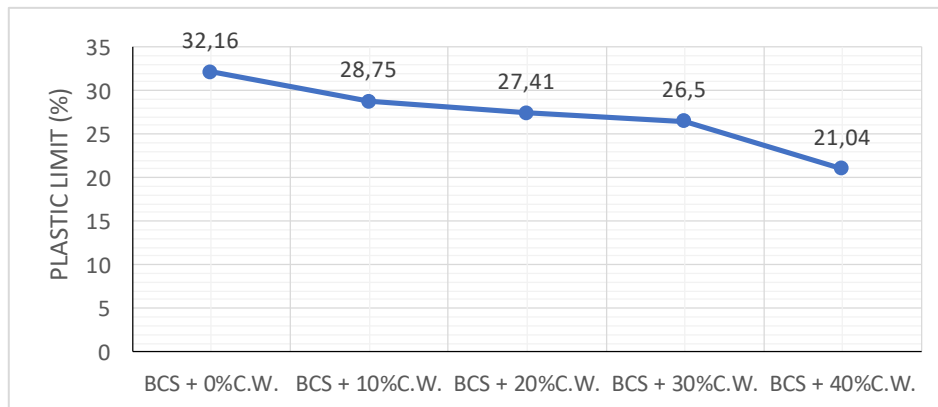


Fig.3 Plastic limit result with varying percentage of ceramic waste

The obtained result of plastic limit treated with different percentage of tile waste as shown in fig.3 From the fig3 it can be seen that with increase in percentage of ceramic waste the plastic limit of soil decreases from 32.16 to 27.41.

5.2 STANDARD PROCTOR TEST

This test is used to determine optimum moisture content and the corresponding dry density of the soil sample passing through 4.75mm sieve and mixed with different percentage of ceramic waste. About 2.5kg of soil sample is taken and then compacted in three equal layers by giving 25 blows using rammer weighing 2.6kg dropping from a height of 31cm. The test were conducted on soil sample according to IS2720 part7-1980.

Table.2 Determination of dry density of sample replaced with varying percentage of tiles waste and NaOH

% of Ceramic waste	MDD(gm/cc)	OMC
0%	1.38	32%
10%	1.41	28.3%
20%	1.53	25.53%
30%	1.438	21.25%
40%	1.82	30.65%



The table 2 shows the value of maximum dry density and optimum moisture content with varying percentage of ceramic waste. From the table it can be seen that the maximum dry density and gradually increases with the addition of ceramic waste up to 20% and decreases beyond this limit

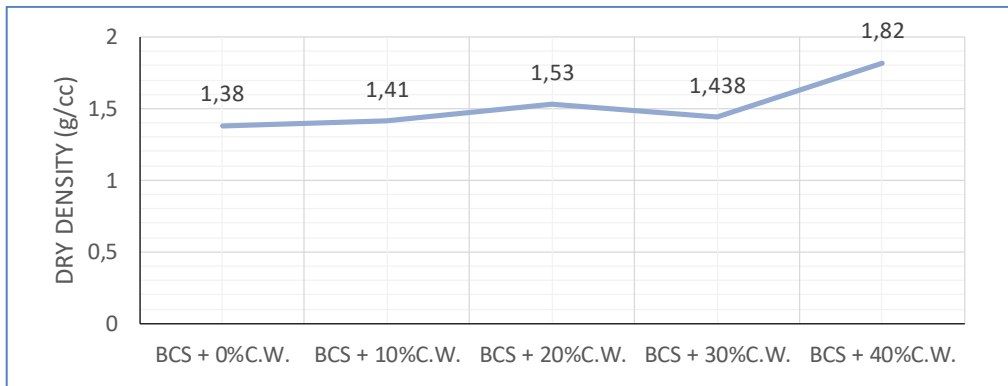


Fig.4 Variation of maximum dry density on different percentage of ceramic waste

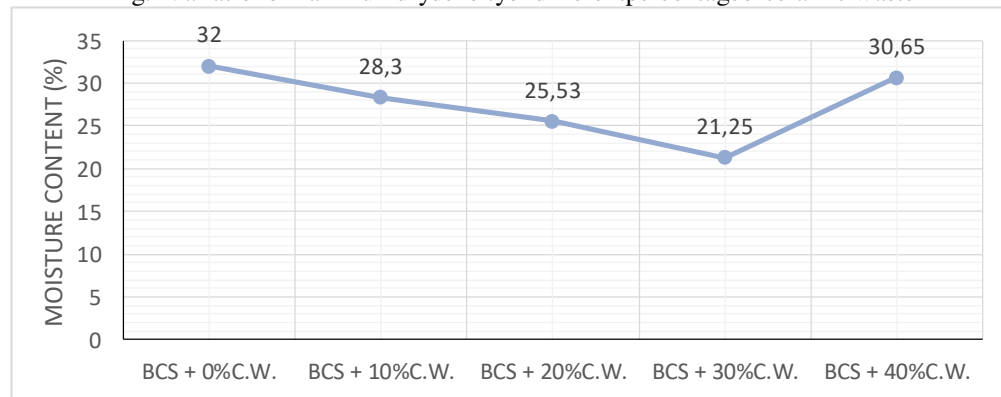


Fig.5 Variation of optimum moisture content on different percentage of ceramic waste

From the fig.4 and fig.5 it can be evaluated that the addition of ceramic waste increases maximum dry density from 1.38 to 1.53. The optimum moisture content decreases with addition of ceramic waste.

5.3 CALIFORNIA BEARING RATIO TEST

This test is used to determine the California Bearing Ratio (C.B.R) of a compacted soil sample in unsoaked condition. The expansive soil is mixed with varying percentage of ceramic waste and then the soil is compacted in the mould and load is applied and reading is taken at penetration of 0.5, 1, 1.5, 2, 2.5, 5, 7.5, 10, 12.5mm respectively.

Table.3 Determination of CBR value of sample replaced with varying percentage of ceramic waste

% of Tiles waste	CBR value(@ 2.5mm penetration)
0%	3.00
10%	5.29
20%	6.58
30%	7.17
40%	9.08

The table 3 shows the value of CBR value at 2.5mm penetration with varying percentage of ceramic waste. From the table it can be seen that the CBR gradually increases with the addition of ceramic waste.

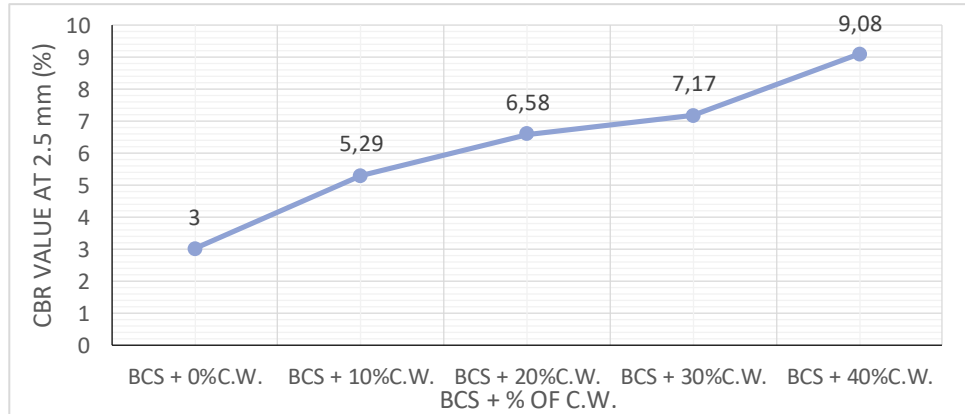


Fig.6 Variation of CBR value on replacement of % of ceramic waste

From the fig 6 it can be seen that the CBR value increases from 3.00 to 6.58% with the addition of ceramic waste.

VI. CONCLUSION

A series of laboratory test is conducted on selected soil sample to study the effect of ceramic waste on the soil. Based on the laboratory results, the following conclusions were made,

- The addition of ceramic waste decreases the liquid limit and plastic limit of the soil up to 20% and it increases beyond this limit.
- The addition of ceramic waste changes the soil group from CH to ML according to IS 1498- 1970.
- MDD increase with increase in % of ceramic waste and OMC decreases with increase in % of ceramic waste.
- The CBR value increase with increase in addition of ceramic waste.
- For CBR value of 3.00% the pavement thickness provided must be 420mm as per SP:20-2002
- The design thickness of flexible pavement after stabilization of weak subgrade with 20% ceramic waste is obtained as 250mm.

From the above results, it can conclude that addition of ceramic waste up to 20% is recommended.

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