

An Experimental Study on Strength Characteristics of Expansive Soil Treated With Mill Scale

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ABSTRACT: The present paper deals with the evaluation of the properties of black cotton soil mixed with mill scale in varying proportions and comparing the same with the results of pure black cotton soil. The mechanical properties of mill scale and black cotton soil are individually determined first and then the two are combined in varying proportions. The properties like OMC and MDD, Unconfined Compressive Strength, and CBR are evaluated in different percentages of Mill scale varying from 3% to 21% with an interval of 3% i.e. 3%, 6%, 9%, 12%, 15%, 18%, and 21%. Added to dry weight of soil it is found that mixing mill scale in varying proportions increases the Bearing Capacity of the soil, strength characteristics.

KEYWORDS: Black cotton soil, Mill Scale, Standard Compaction test, UCC, and CBR.

1. INTRODUCTION

Expansive clay or Expansive soil is a clay or soil that is prone to large volume changes (swelling and shrinking) that are directly related to changes in water content. Soils with a high content of expansive minerals can form deep cracks in drier seasons or years and such soils are also called as vertisols. Soil stabilization refers to the process of changing soil properties to improve strength and durability. There are many techniques for soil stabilization, including compaction, dewatering and by adding minerals to the soil. Expansive soils popularly referred to as black cotton soils in India area unit one in every of the key regional deposits of India covering a part of regarding one fifth of the country's area (about three lakhs sq. km). Expansive soils swell and shrink in a much marketed method as a result of gain or loss in moisture content. In general, expansive soils have high plasticity, and are comparatively stiff.

Expansive soils have been reported from many parts of the world, mainly in the arid or semi-arid regions of the tropical and temperate zones like Africa, Australia, India, South America, United States, and some regions in Canada. However, in the humid regions water tables are generally at shallow depth and moisture changes. (Arnold, 1984; Shuai and Fredlund, 1998; Wayne et al. 1984).

II. LITERATURE REVIEW

Y.I Murthy (2012) presented that the expansive soil can be stabilized by using the mill waste. During this analysis, it's been seen that the physical and mechanical properties of soil will be modified by using the mill waste as a addition to the expansive soil. It's been seen that the bearing capacity of soil will be increased up to a particular quantity of mill waste adding within the soil. According to the study it shows that a permeability of soil will increase however the plasticity of soil decreases by increasing the quantity of mill waste. The attainable use of steel mill Scale can reduce the importation of cement and associated foreign exchange difficulties. the utilization of steel mill Scale in soil stabilization is thus of abundant economic and environmental profit. The steel mill Scale was ground into powder and mixed with black cotton soil in numerous proportions.

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Kiran R. G. Kiran L (2010) had studied “The analysis of Strength Characteristics of Black Cotton Soil Using Mill Scale and Additives as Stabilizer”. In this study the black cotton soil is stabilized with different percentage of Mill Scale (4%, 8% and 12%). The strength parameters like CBR, UCS are determined and observed the MDD value increases upto 8% replacement and CBR, UCS values also increases maximum on optimum percentage i.e. 8%, beyond which further decreases.

Pereira et al. (2011) on the use of mill scale as fine aggregate in concrete have shown that mill scale demands greater water content to maintain the workability. The results indicated that concretes with water/cement ratios of 0.55 and 0.65 have higher compressive strength and greater water absorption as the mill scale content increase. This paper presents the findings of a study that investigates the potential for recycling steel mill scale into concrete. The composition of steel mill scale was determined by XRD analysis. For mortar samples, river sand was replaced by 20%, 40%, 60%, 80% and 100% mill scale whereas, for concrete cubes, the replacement was restricted to only 80% as the weight of concrete was increasing at a very fast rate and complete sand replacement did not seem practical. Compressive strength and tensile strength were measured for different specimens of the mortar and concrete samples. The results are promising and encourage further study in applications in concrete, brick and block manufacturing.

III. MATERIALS AND METHODOLOGY

A. MATERIALS:

- Expansive soil
- Mill Scale

In the current work, as stated above the soil is collected from Pendlimarri village of Kadapa district and whereas the Mill scale is obtained from a metal industry of Hyderabad. The soil is treated with different proportions of Mill scale and the tests were conducted. From the initial experimental test analysis the soil is classified as silts with high compressibility clays.

B. METHODOLOGY:

Index and Engineering properties of the collected soil was found in the laboratory of KSRM college of Engineering and Technology, results are tabulated below.

Table3.1 Chemical Properties of Mill Scale

Chemical	Typical %
Fe ₂ O ₃	93.61
MnO	1.53
TiO ₂	0.014
SiO ₂	1.87
MgO	0.28
CaO	0.111
Na ₂ O	0.013
Al ₂ O ₃	0.099

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Table 3.2 Properties of Original Black Cotton Soil

S.no	Experiments	Experimental Values
1	Specific Gravity	2.29
2	Differential Free Swell Index (%)	100
3	Grain Size Analysis Gravel (%) Sand (%) Silt (%) Clay (%)	0.8 18.62 42.69 37.89
4	Atterberg Limits Liquid Limit (%) Plastic Limit (%) Shrinkage Limit (%) Plasticity index (%)	73.40 44.80 22.00 33.85
5	Standard Proctor Test Optimum Moisture Content (%) Maximum Dry Density (g/cc)	27 1.38
6	Unconfined Compression Test (kg/cm ²)	0.12
7	California Bearing Ratio (%) Unsoaked Soaked	1.54 1.45
8	Indian Classification Of Soil	MH

The collected soil is treated with Mill Scale in varying percentages from 3% to 21% in the interval of 3% to the dry weight of the soil. UCS, CBR and Standard Compaction Tests are carried out to find Shear Strength, CBR value and Dry Density.

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IV. RESULTS AND DISCUSSION

A. STANDARD COMPACTION TEST:

Compaction is a mechanical process in which the densification is achieved through the expulsion of air voids at almost constant water content of the soil mass. While the compaction is relatively an instantaneous process, consolidation is a time dependent process.

Table4.1MDD values for different percentages of Mill scale

Mill scale%	0	3	6	9	12	15	18	21
MDD values	1.38	1.42	1.48	1.52	1.54	1.58	1.61	1.63

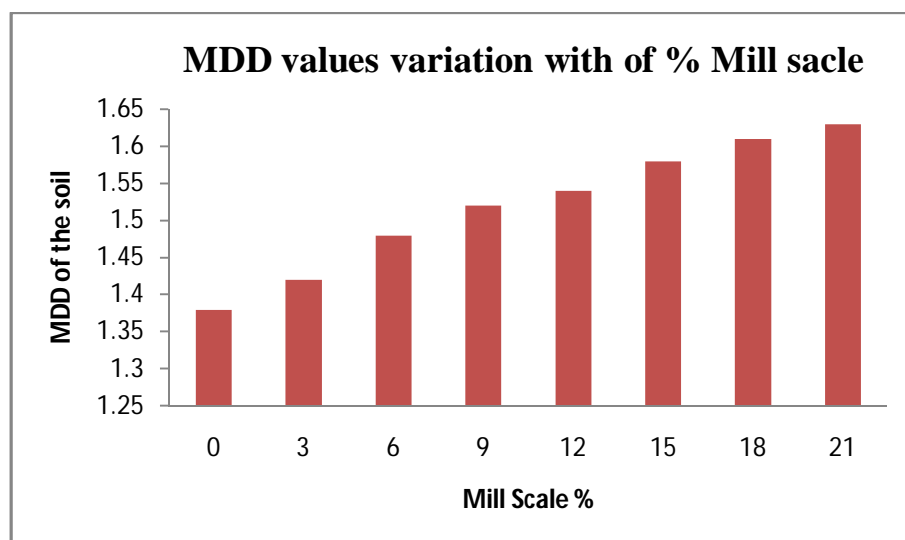


Fig4.1 Variations in the MDD values of soil samples for various percentages of Mill scale

B. UNCONFINED COMPRESSION TEST:

An Unconfined compression test is also known as uniaxial compression tests, is special case of a triaxial test, where confining pressure is zero. UC test does not require the sophisticated triaxial setup and is simpler and quicker test to perform as compared to triaxial test. In this test, a cylinder of soil without lateral support is tested to failure in simple compression, at a constant rate of strain. The compressive load per unit area required to fail the specimen as called **unconfined compressive** strength of the soil.

The UCS is test performed for Expansive Soil treated with Mill scale varying from 3% to 21% with an interval of 3% i.e. 3%, 6%, 9%, 12%, 15%, 18%, and 21%. Added to dry weight of soil. The test results are determined below in the table.

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Table 4.2 Unconfined compression strength values for percentage of mill scale

Mill scale	0	3	6	9	12	15	18	21
Ucc strength	0.12	0.1456	0.1669	0.1974	0.2207	0.2461	0.2782	0.2974

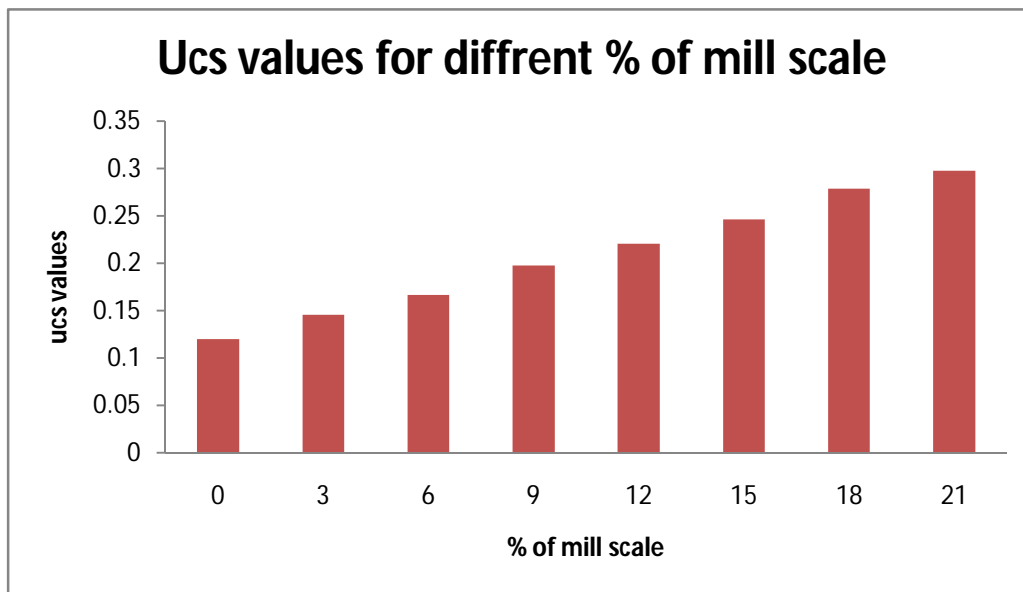


Fig 4.2: Unconfined compressive strength results for % of mill scale

C. CALIFORNIA BEARING RATIO TEST:

The CBR method is based on strength parameter of the material and is, therefore, more rational than the group index method. The basic assumption in the method is that a layer of pavement is of superior quality than the layer below it. The shortcoming of the method is that it gives the same total thickness above a material irrespective of the quality of the overlying layers

4.3.1 CBR Unsoaked and Soaked

The unsoaked and soaked CBR experiments are conducted for the soil samples treated with various percentages of Mill scale. The CBR values of untreated black cotton soil and the soil samples treated with Mill scale percentages are shown in the tables below. The value of unsoaked CBR is 1.54 at 5mm penetration whereas the soaked CBR value is 1.45 at 5mm penetration. The CBR values are generated from the load Vs penetration curve. The CBR values of all the samples at 5mm penetration are less than the values at 2.5mm penetration. The CBR values of all the samples treated with Mill scale are represented in the figures given below.

As observed from the test results the CBR values of both unsoaked and soaked CBR values are lesser for the untreated or original soil whereas the CBR values of soil treated with Mill scale are significantly high.

Thus it can be considered that the soil sample used in the present study with Mill scale shows significant performance at higher dosages of Mill scale where as there is continuous increment in the CBR values with the increase in percentage of Mill scale Hence the amount of Mill scale percentage to be utilised for soil is dependent on the required strength criteria in the field.

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Table 4.3 Unsoaked CBR strength for various percentages of Mill scale

Mill scale	0	3	6	9	12	15	18	21
Unsoaked CBR values	1.54	1.99	3.53	5.29	6	7.74	8.48	9.25

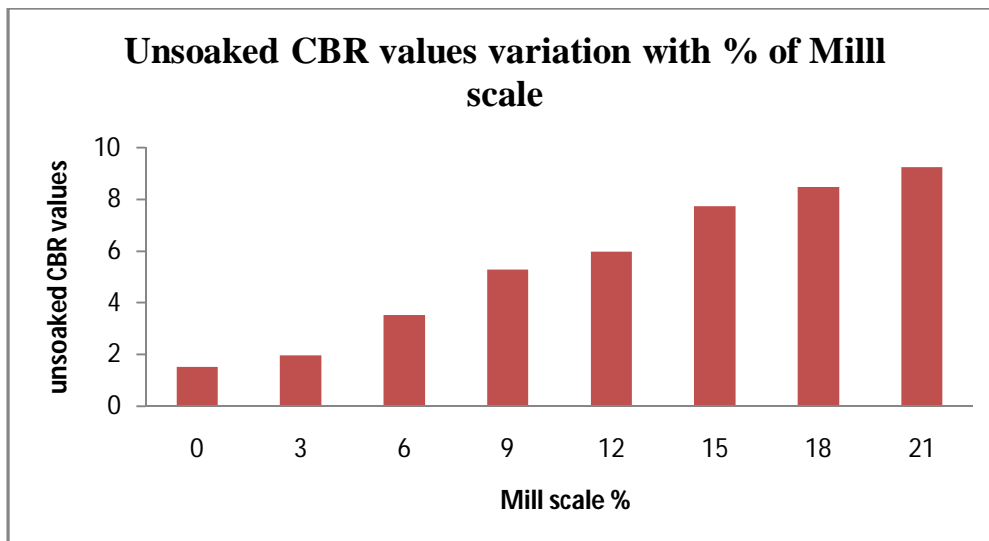


Fig4.3: Variations in the Unsoaked CBR values of soil samples for various percentages of Mill scale

Table 4.4: Soaked CBR strength for various percentages of Mill scale

Mill scale	0	3	6	9	12	15	18	21
Soaked CBR values	1.50	1.76	2.85	4.58	5.72	6.69	8.11	8.38

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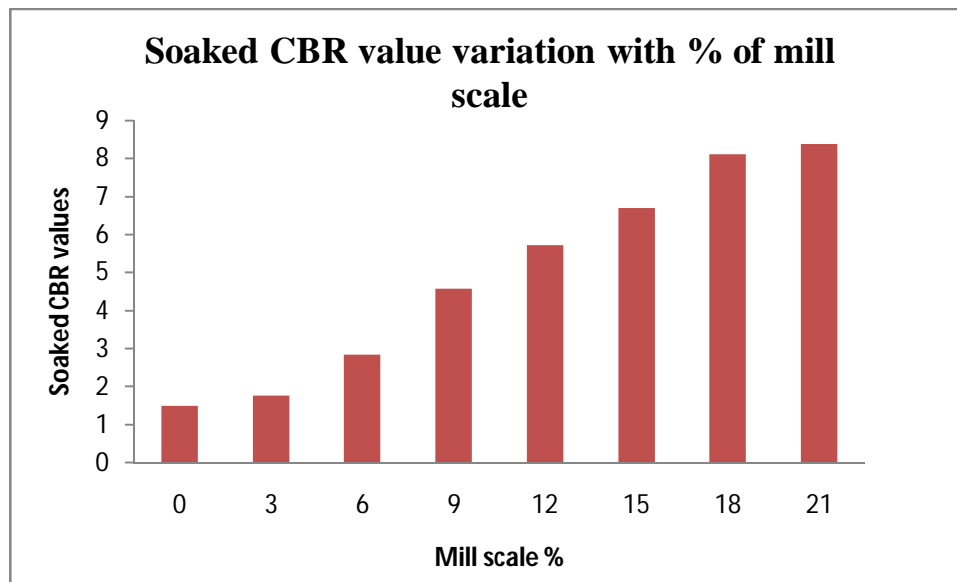


Fig 4.4: Variations in the Soaked CBR values of soil samples for various percentages of Mill scale

V. CONCLUSIONS

1. Compaction, Strength and Swelling characteristics of Expansive soils are dependent on coarse fraction present in the soil. The Coarse fraction decreases OMC, increases MDD and CBR, but effect is insignificant for coarse fraction less than 30% to 40% by weight of soil. Unconfined compressive strength decreases with coarse fraction but effect being insignificant for coarse fraction more than 30% to 40% by weight of soil.
2. The CBR test done for original black cotton soil is observed to be very less when compared to the CBR values resulted for the soils samples treated with Mill scale
3. For every increase in percentage of Mill scale there is a considerable increment in the Standard compaction test, UCC and CBR values of the soils.
4. With increase in percentage of Mill scale the shear strength of the soil increased from 1.38 to 1.63, obtained at 21% of mill scale added to the dry weight of soil. The Percentage increase is 118.11%.
5. With increase in percentage of Mill scale the shear strength of the soil increased from 0.12 to 0.2974, obtained at 21% of mill scale added to the dry weight of soil. The Percentage increase is 147.83%.
6. With increase in percentages of Mill scale the Unsoaked CBR value is increased from 1.66 to 10.29, obtained at 21% of Mill scale added to the dry weight of soil. The percentage increase is 519.87 compared to untreated soil
7. With increase in percentages of Mill scale the soaked CBR value is increased from 1.54 to 9.37, obtained at 21% of Mill scale added to the dry weight of soil. The percentage increase is 508.87% compared to untreated soil

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