USE OF CEMENT AND DEMOLITION WASTE FOR SOIL STABILZATION IN HIGHWAY SUBGRADE

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ABSTRACT

Clayey soils are often associated with low bearing capacity, high shrinkage and swell characteristics so it becomes necessary to stabilize such soils. In this study an effort has been made to improve the strength properties of clayey soil. The proportion used of ordinary Portland cement was 3, 6% and that of fine recycled Construction and Demolition waste (passing 1.18 mm sieve) was 10, 20, 30and 40%. Due to high exploitation of natural materials, there is a great need to identify and use the waste materials in the best possible way in order to lessen the burden on the natural materials. Secondly, use of waste materials may also resolve the problem of their disposal, hence helping in avoiding the pollution due to this disposal process. Among many waste material, CDW may also be used under the theme of reduce, recycle and reuse and it has been already proven by many researchers that such waste can be effectively utilized as a stabilizing agent for adverse soils. Further, cement as a binder is very well renowned admixture for such soils. Compaction characteristics and CBR value (soaked and unsoaked) of various samples were studied with such admixtures and stabilizers. From compaction characteristics it was observed that with increase in various percentages of CDW (up to 30%), with variation of 10% and cement content (0-6%), with variation of 3%, CBR has improved significantly for both the soaked and unsoaked conditions. Maximum dry density increases with the increase in percentage of CDW and Cement. Optimum Moisture Content decreases with the increase in CDW. With inclusion and increase in cement content, the MDD as well OMC increase. But CBR for both soaked and unsoaked cases started falling for CDW beyond 30 %. But, overall it has been shown in this study that CDW and cement can be effectively used to improve the properties of clayey soil masses making them a better material to be used to construct highway sub-grade as indicated ahead in this report.

KEY WORDS:

Soil, Sub-grade, California Bearing Ratio, Stabilisation, Cement and Construction and Demolition waste.

I. INTRODUCTION

Soil stabilisation is the process of alteration of soils in order to enhance its properties. Soil stabilisation not only increases the shear strength of soil but also helps to control the swell and shrink properties of soil, thus improving the load bearing capacity of soil subgrade to support pavements. The word soil is derived from the 'Latin' word 'Solium'. The word 'Solium' in 'Latin' means the top layer of the earth on which plants grow according to Webster's dictionary. Generally, soil consists of water, air and solid particles. Soil is formed either by physical weathering or by chemical weathering. Beside the complexity of understanding soil, geotechnical engineers made their best efforts to group the soil based on its specific response to different environmental conditions. Soil can be classified as highly compressible and soil of low compressibility, expansive and non-expansive, sensitive & insensitive, highly plastic, very soft to stiff clay, loose and dense sand, etc.

II. MATERIALS AND METHODS

The various materials used in this study are soil, construction and demolition waste and cement. It becomes necessary from engineer's point of view to study the characteristics of the material used in the research work. The properties of the subgrade material were found as per Indian standards and the result obtained are tabulated below:

Sr.	Properties	Value
1	Colour	Brown
2	Liquid Limit (%)	42.1
3	Plastic Limit (%)	22.0
4	Plasticity Index (%)	20.1
5	Soil Type as per ISC	CI
6	Optimum Water Content (%)	14.4
7	Maximum Dry Density (g/cc)	1.84
8	Unsoaked California Bearing Ratio (%)	5.6
9	Soaked California Bearing Ratio (%)	2.6
10	Specific Gravity	2.70

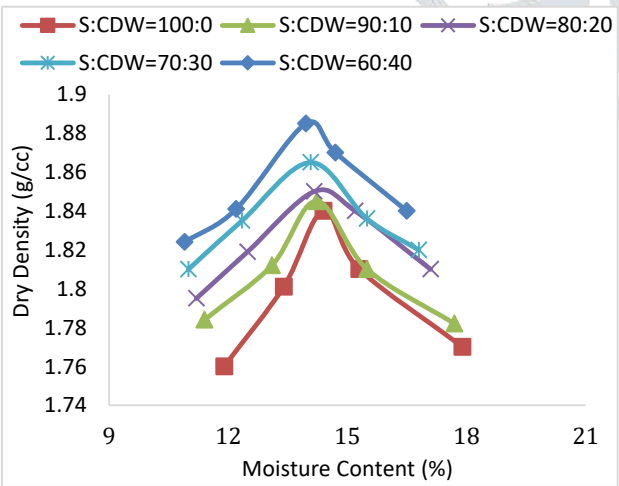
CDW used in this study was obtained from a demolished building. The waste was in the form of concrete and plaster. This waste was manually crushed by hammer and then sieved. The crushed concrete and plaster was sieved through 1.18 mm sieve. The material passing through 1.18 mm sieved was used. Specific gravity of CDW of size < 1.18mm was found to be 2.60.

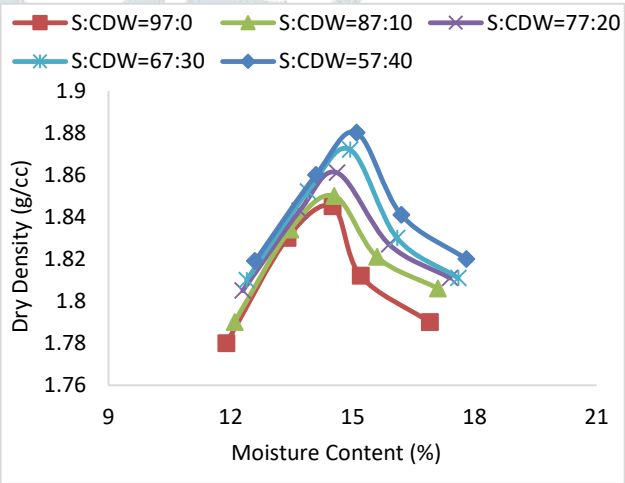
III. EXPERIMENTAL PROGRAM

Various tests were conducted as per IS codes in this study to determine the engineering properties of stabilized soil and effect of CDW and Cement on soil.

Standard Proctor test

Moisture content and dry density relationship of virgin soil and soil mixed with different percentage of soil, CDW and cement were investigated by carrying out standard Proctor compaction test as per IS:2720 (part 8). To determine the water content-dry density relation, modified compaction tests (heavy compaction test) were conducted on plain soil and soil admixed with fines. Compaction was done manually. Firstly, the tests were conducted on plain soil sample by varying the percentage of water in order to find optimum water content and maximum dry density. Later on, the tests were conducted on soil admixed with fines and cement at different variations. The results are shown as under:





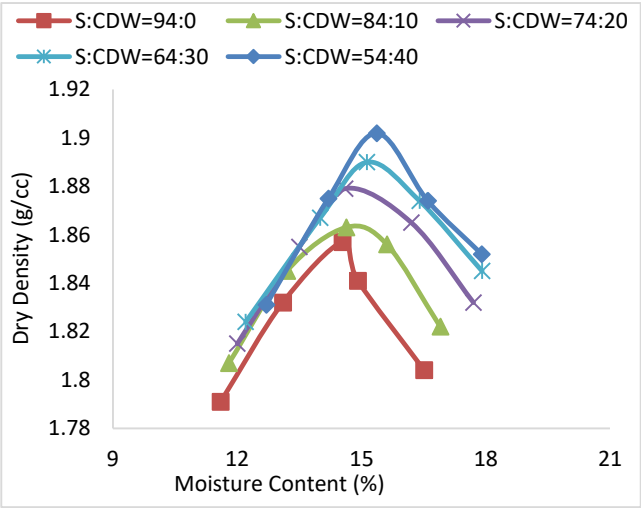


Fig. 1 Dry density versus moisture content (%) for different combinations of mixes at 0%,3% and 6% cement.

California bearing ratio

California Bearing Ratio (CBR) test is an important test of subgrade soil performed to evaluate the suitability of subgrade soil in design of pavement. CBR tests (both Unsoaked and soaked) were performed on various soil samples mixed with CDW and cement as per IS: 2720 (Part 16). Unsoaked CBR was conducted on the fresh samples of soil. For soaked CBR, each sample was soaked for 4 days and finally CBR test was performed

$$\text{CBR value} = \frac{\text{Test Load Corresponding to 2.5 mm penetration or 5 mm penetration (whichever is higher)}}{\text{Standard Load Corresponding to the above penetration}} \times 100$$

CBR is always in percentage.

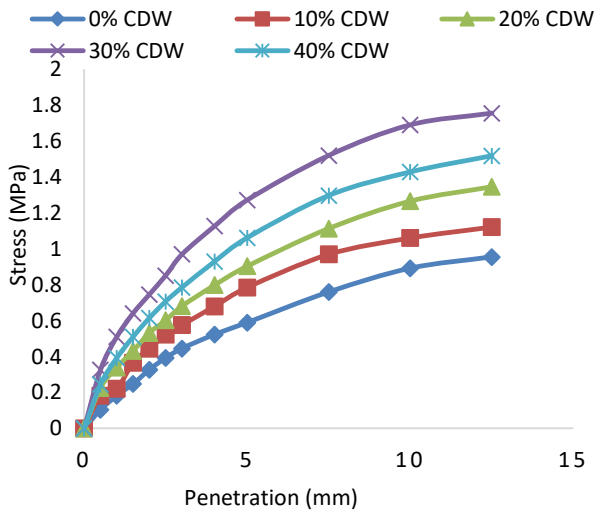


Fig.2 Stress-penetration behaviour for different combination of soil and CDW mix with 0% cement (Unsoaked)

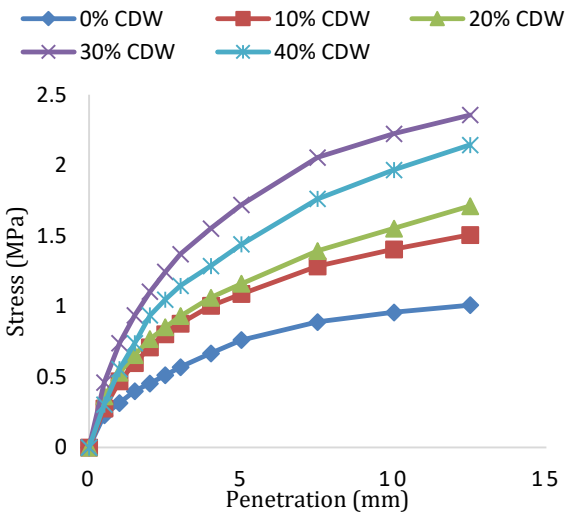


Fig.3 Stress-penetration behaviour for different combination of soil and CDW mix with 3% cement (Unsoaked)

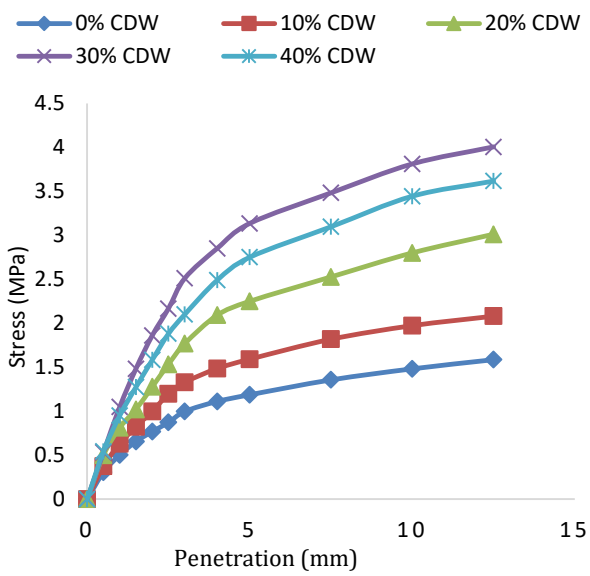


Fig.4 Stress-penetration behaviour for different combination of soil and CDW mix with 6% cement (Unsoaked)

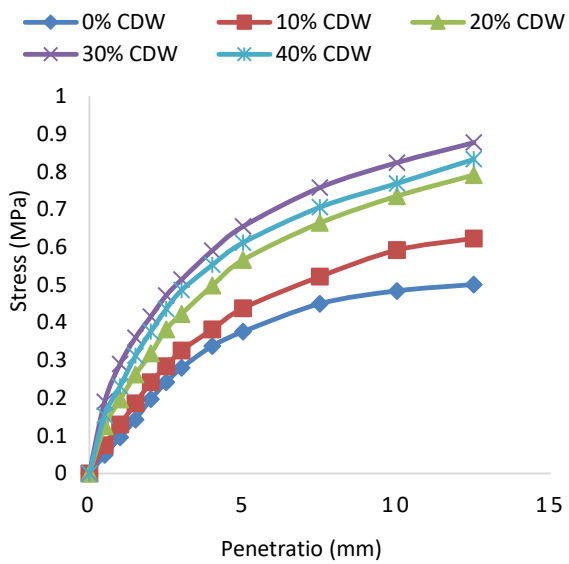


Fig.5 Stress-penetration behaviour for different combination of soil and CDW mix with 0% cement (Soaked)

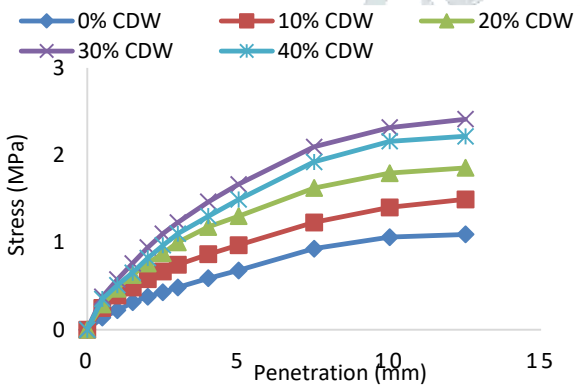


Fig.6 Stress-penetration behaviour for different combination of soil and CDW mix with 3% cement (Soaked)

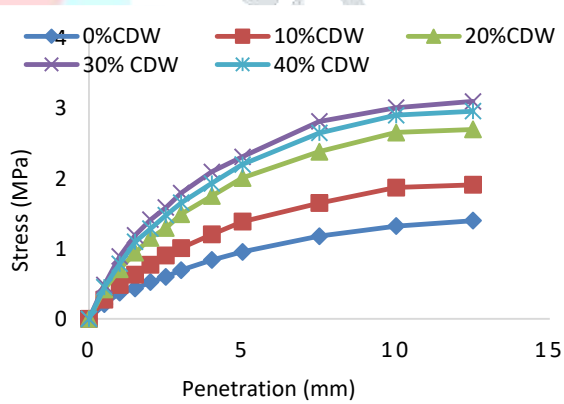


Fig 7 Stress-Penetration behaviour for different Combinations of soil and CDW with 6% cement (Soaked)

IV. RESULTS AND DISCUSSION

The aim of this study is to analyse the improvement in the geotechnical properties of clayey soil like Compaction Characteristics, California Bearing Ratio (soaked and unsoaked) values with utilization of construction and demolition waste (CDW) and cement at different variations. The standard Proctor compaction test was carried out on the virgin soil and Construction and Demolition Wastes (CDW)-Cement mixture proportions. The compaction tests were performed for various combinations of CDW-soil-cement mixtures. From the results, it is observed that with the addition of CDW, there is slight increase in MDD and decrease in OMC. With inclusion and increase in cement content, the MDD as well OMC of soil-cement mixes increase. The maximum dry density of the mix is observed as 1.902 g/cc at OMC of 15.37%

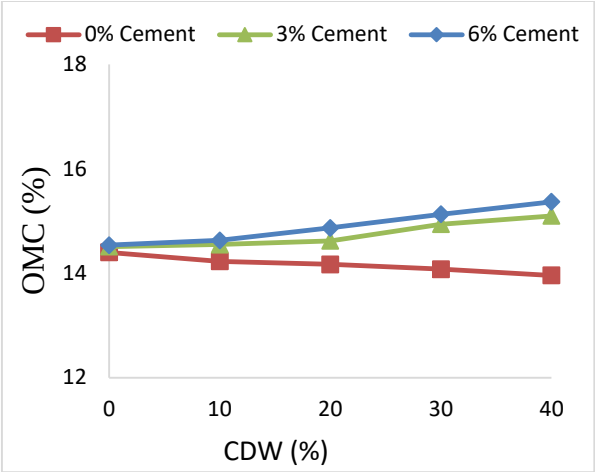


Fig.8 OMC (%) versus CDW (%) by replacement of clay with different percentages of CDW and cement

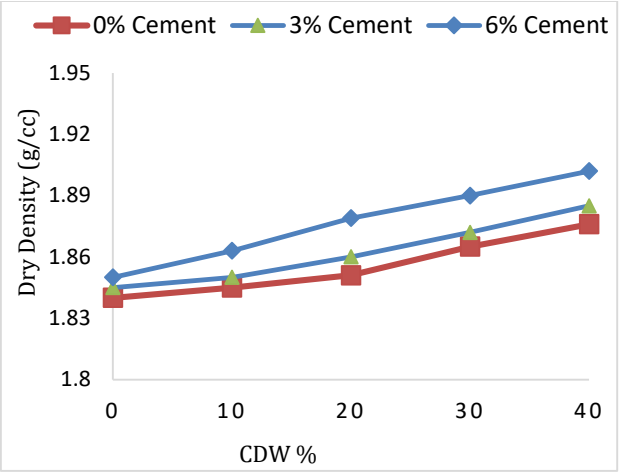
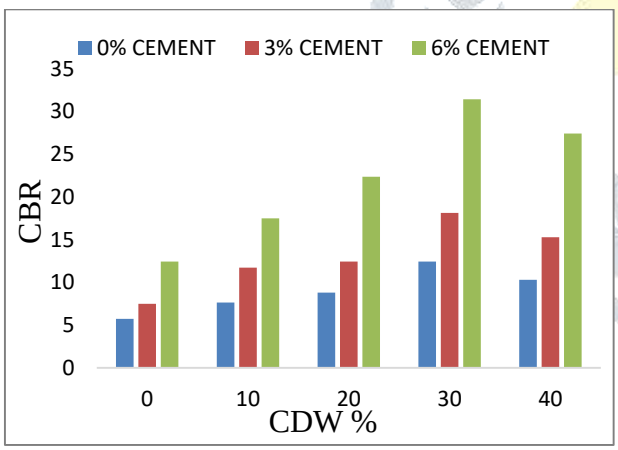


Fig.9 Maximum Dry Density (%) versus CDW (%) by replacement of clay with different percentages of CDW and cement

The CBR value of the sub grade is an important factor for designing the pavement thickness composition. The CBR value is commonly used to evaluate the quality of road materials. The unstabilized soil had the smallest CBR value at 3.6% for soaked and 5.72% for unsoaked. The cement-CDW mixture enhanced the bearing of soil in which the CBR improvement was because of the cementing pozzolanic reaction between the soil and cement-CDW material. The optimum dose of CDW and cement has been found to be 30% and 6%, respectively both for soaked as well as unsoaked conditions of CBR values. Beyond this, with increasing CDW both soaked and unsoaked CBR values fall, which may be resulted due to reduction in cohesion. The supporting variations of results in terms of graphs have been shown below



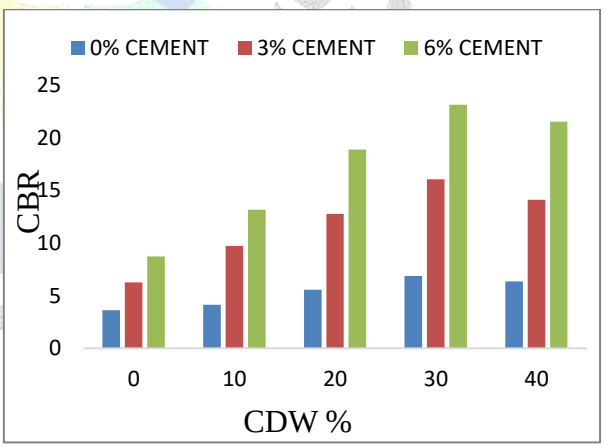


Fig.10 Variation of soaked CBR (%) with CDW (%) at different cement contents. Fig.11 Variation of unsoaked CBR (%) with CDW (%) at different cement contents

V. CONCLUSION:

From the above experimental investigation following conclusion have been drawn:

- In this study it was concluded that good quality of road material can be generated by recycling CDW and by using CDW, natural aggregates can be saved for future.
- It was studied that OMC decreases from 14.4% for virgin soil to 13.96% for soil with CDW 40%. With inclusion and increase in cement content, OMC of the mixes increase from 14.51% for soil with 3% Cement to 15.37% for soil with 40% CDW and 6% cement.
- MDD increases from 1.84 g/cc for virgin soil to 1.902 g/cc for soil with 40% CDW and 6% Cement.

- Strength in terms of Unsoaked CBR increases from 5.72% to 31.41% at optimum of 30 % CDW and 6% cement by dry soil weight and Soaked CBR increases from 3.6% to 23.119% at optimum of 30% CDW and 6% cement by dry soil weight.
- Recycled CDW can reduce the demand-supply gap of natural aggregates and will also reduce construction and demolition waste.

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