An Experimental Study on Expansive Soil using Construction & Demolition Waste

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Abstract-With the increasing of population and due to high consumption of construction materials the scarcity of land as well as natural construction material causes inflation in the construction market. To counteract the first problem i.e. land demand we have to stabilize poor soil (expansive soil) and for second one we have to use recycled material. As per data of ICAR73.2 million hectares of land area in India are covered with expansive soil. Expansive soils swell when they come in contact with water and shrink when they become dry. Expansive soil offers poor shear strength, high swelling and shrinkage, a great diversity of ground improvement techniques such as soil stabilization and reinforcement are deployed to improve mechanical behavior of soil, thereby enhancing the engineering properties of the soil, such as volume stability, shear strength and durability. In process of soil stabilization and reinforcement, removal or partial replacement of the problematic soil is done with an additive (brick dust and concrete dust).

In this study it is demonstrated that the C&D waste has a huge potential in decreasing material use as an additive. By recycling C&D waste, crushed brick dust & concrete dust are used in present study. With various proportions of brick dust additive i.e. 8%, 16%, 24%, 32% & 40% and concrete dust additive i.e. 5%, 10%, 15%, 20% & 25% expansive soils is stabilized. After stabilization of expansive soil in laboratory changes in various soil properties such as Maximum Dry Density, Optimum Moisture Content, and California Bearing Ratio, Unconfined compressive strength was studied.

INTRODUCTION

General

For construction of any structure, it is the responsibility of a geotechnical engineer to investigate and evaluate the geotechnical and engineering properties of the soil below the base. Based on the evaluation of these properties, the appropriate material and method can be selected in order to modify the engineering properties of soil and to fix the suitably with various materials. In this work, an attempt has been made to modify the properties of expansive soil using Construction and demolition waste.

Expansive soil

Expansive soils are predominant in many parts of the world. The variation of water content lead to cracking of the structures built on them. When water comes into contact with expansive soil, its volume swells means volume increases and when water evaporated from expansive soil, its volume decreases and soil shrinks. Volume changes due to change in moisture content causes settlements of foundations, damage to the pavements and other problems related with civil engineering. During periods of greater moisture, like monsoons, these soils imbibe the water and swell subsequently, they become soft and their water holding capacity diminishes. As opposed to this in drier seasons like summers, these soils lose the moisture held in them due to evaporation, resulting in their becoming harder.

Expansive soils are vastly spread in the regions of middle India Andhra Pradesh, Madhya Pradesh, Gujarat, and Maharashtra and in some places of Orissa, expansive soils are available in the regions of Narmada, Tapti, Krishna, and Godavari. In north western India the depth of availability of expansive soil is very high. The expansive soils are the residual soils formed due to weathering or chemical decomposition of the rock, left at that place itself after formation from the rocks. The expansive soils consist of high percentage of montomorollonite content which is responsible for expansion and shrinkage of the soil. Presently at India nearly 22% of the soils are covered by the expansive soils. These soils are having affinity to hold large moisture content so suitable for the growing of the crops like jower, oilseeds, citrus fruits, cereals, sugarcane and vegetables. Expansive soils are very profitable for the forming and problematic to the constructive point of view.

Characteristics of construction and demolition waste
This category of waste is complex due to the different types of building materials being used but in general may comprise the following materials:
Construction and demolition waste generated by Asian & Developed Countries
Asian institute of technology, Thailand had conducted a survey in various Asian countries and prepared a report regarding the construction and demolition waste management in May 2008. The study includes Asian countries like Bhutan, Japan, Hong-Kong SAR, China, Thailand and others including India. The following i.e. chart shows the status of construction and demolition waste in Asian countries. Figure 1 shows the status of construction waste in Asian countries.

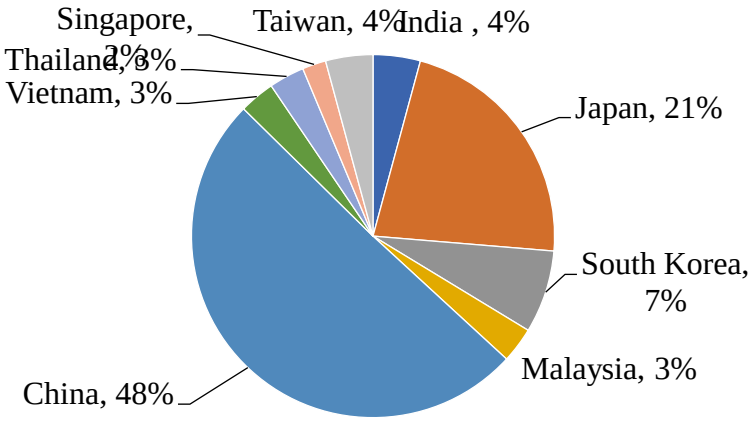

Fig. 1: Estimates of C&D Wastes in Some Asian countries (Asian Institute of Technology, 'Report on reduce, reuse and recycle (3R) practices in construction and demolition waste management in Asia' Thailand, May 2008)

Estimate of C&D waste in India:
It is commonly understood that C&D waste can be considered a resource and can be reused on-site or elsewhere or recycled. Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons per annum out of which, waste from construction industry only accounts for more than 25%. Management of such high quantum of waste puts enormous pressure on solid waste management system. C&D waste can be characterized based on the source of generation or the components of the waste as shown in following figures.

It can also broadly be categorized as mixture C&D waste contains of following materials:

Table -1: Typical composition of Indian C&D waste

Sl.No	Material	Composition %
1	Soil, Sand & Gravel	36
2	Brick & Masonary	31
3	Concrete	23
4	Metals	5
5	Bitumen	2
6	Wood	2
7	Others	1

Source: Technology Information, Forecasting and Assessment Council, Department of Science and Technology, Government of India, 2001

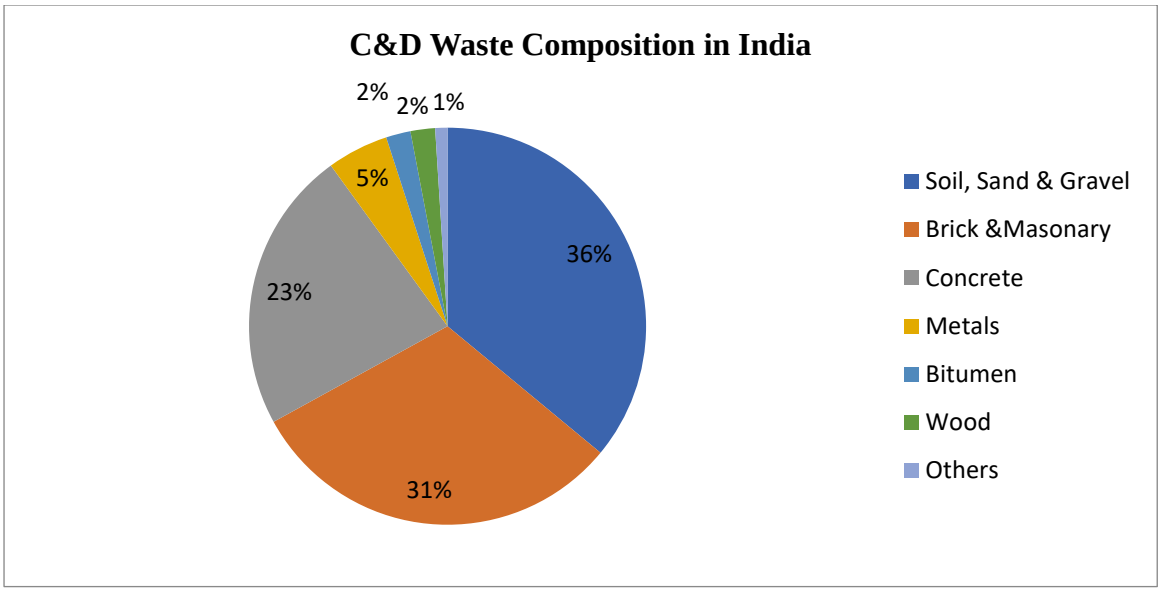

Fig 2 Typical C&D Waste Compositions in India

RESULTS AND DISCUSSIONS

Maximum dry density at different percentage – The results obtained from Proctor compaction test of expansive soil at different percentage of brick dust and concrete dust are as follows

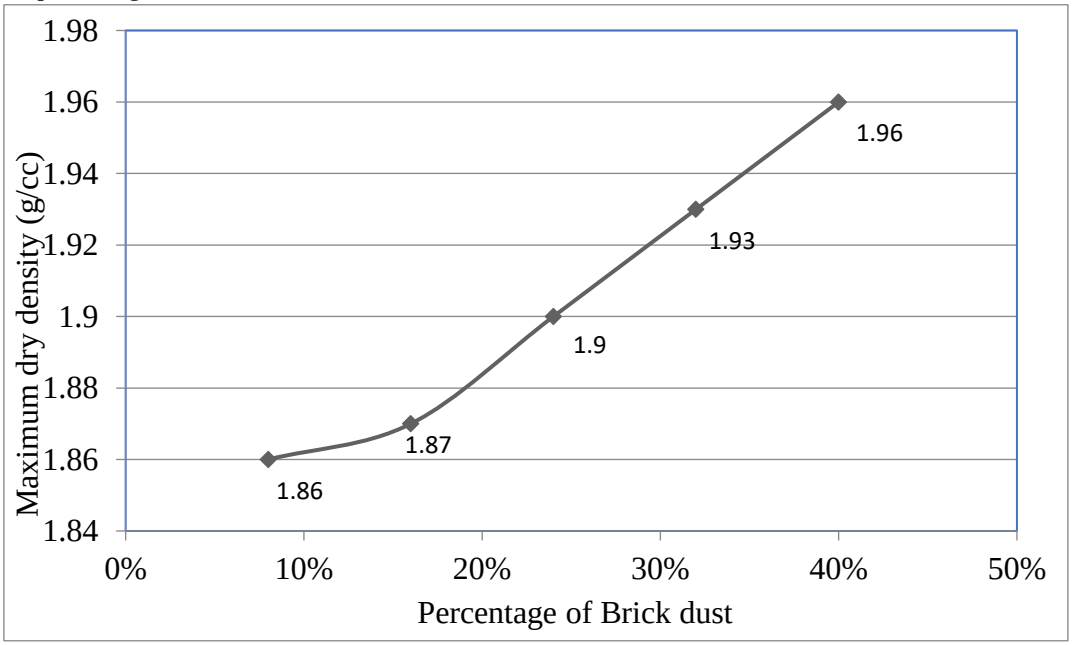

Fig. 3 Maximum dry density at different percentage of brick dust

Table: 2 MDD at different percentage of brick dust

Sl.No	Maximum dry density (g/cc)					
	Virgin soil	Soil+8% Brick dust	Soil+16% Brick dust	Soil+24% Brick dust	Soil+32% Brick dust	Soil+40% Brick dust
1	1.85	1.86	1.87	1.90	1.93	1.96

Table: 3 MDD at different percentage of concrete dust

Sl.No.	Maximum dry density (g/cc)					
	Virgin soil	Soil+5% Concrete dust	Soil+10% Concrete dust	Soil+15% Concrete dust	Soil+20% Concrete dust	Soil+25% Concrete dust
1	1.85	1.87	1.89	1.94	1.97	2

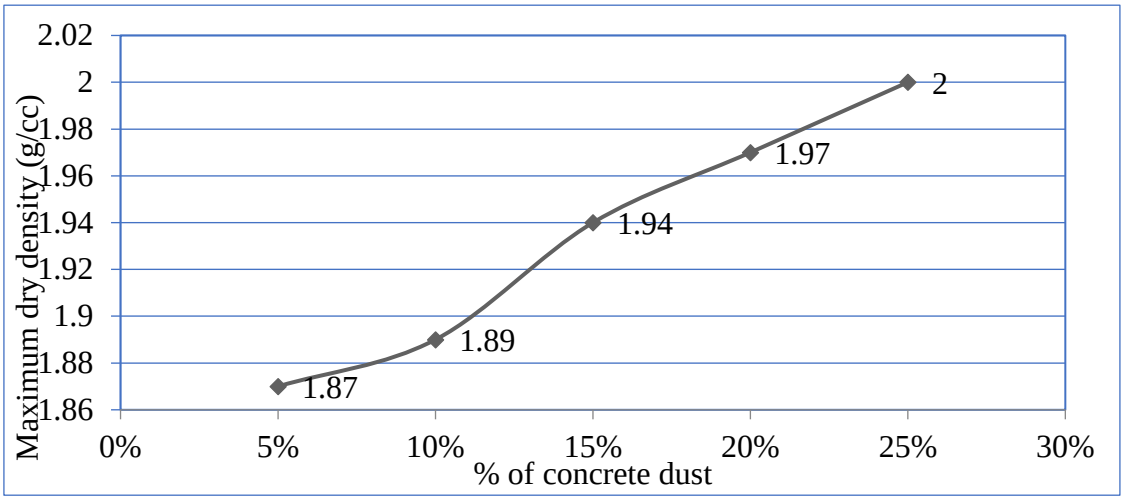

Fig. 3 Maximum dry density at different percentage of Concrete dust

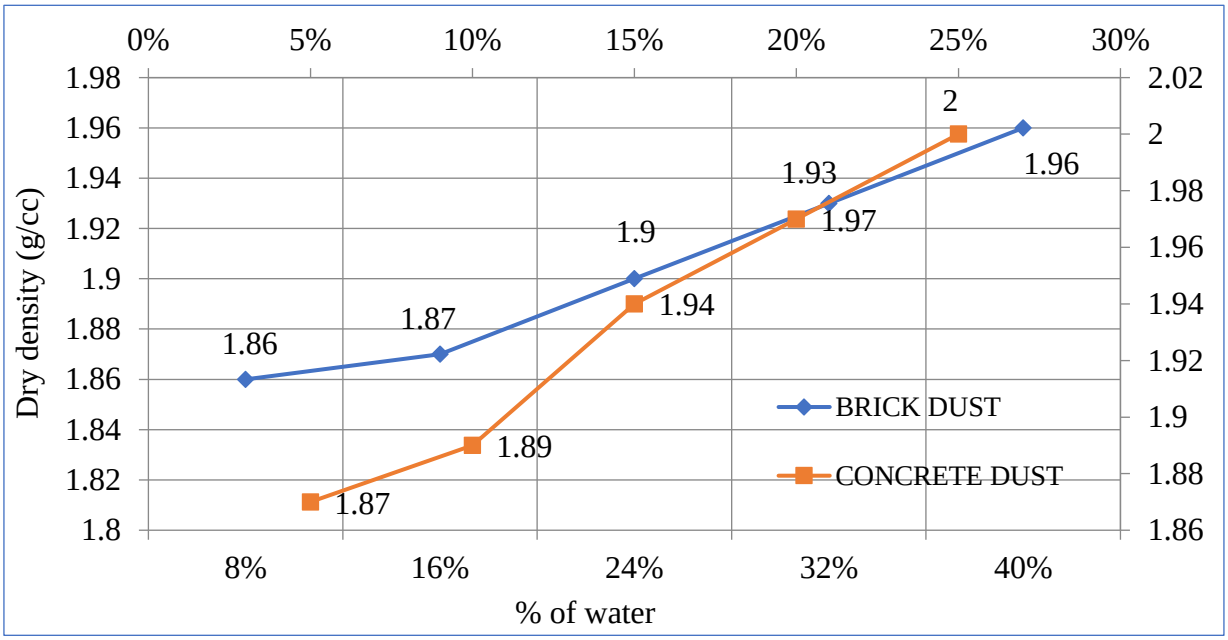

Fig. 4 Maximum dry density at different percentage of Concrete dust & Brick dust

Optimum moisture content at different percentage The results obtained from Proctor compaction test of expansive soil at different percentage of brick dust and concrete dust are as follows-

Table: 4 OMC at different percentage of Brick dust

Sl.No	Optimum moisture content %

	Virgin soil	Soil+8% Brick dust	Soil+16% Brick dust	Soil+24% Brick dust	Soil+32% Brick dust	Soil+40% Brick dust
1	15	16.15	15.27	14.18	13.5	11.52

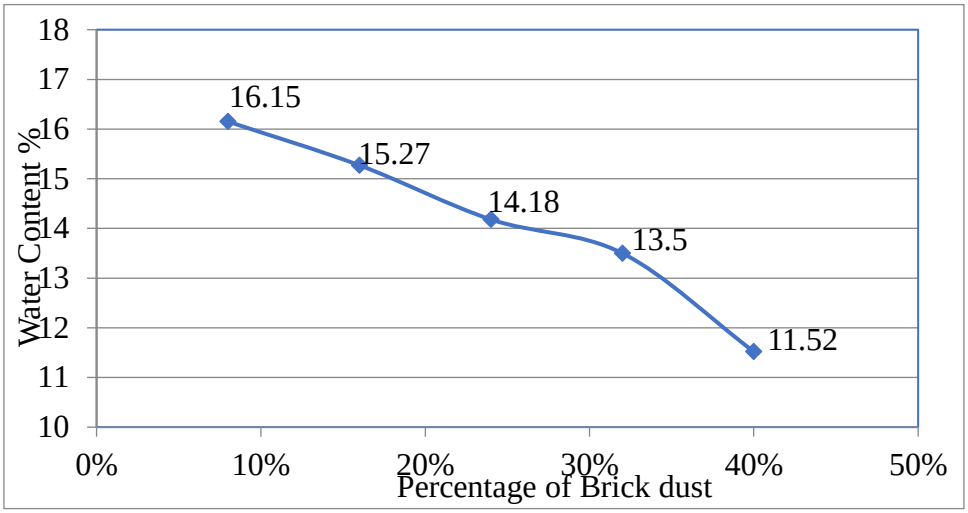

Fig. 5 Optimum moisture content at different percentage of Brick dust

Table: 5 OMC at different percentage of Concrete dust

Sl.No.	Optimum moisture content %					
	Virgin soil	Soil+5% Concrete dust	Soil+10% Concrete dust	Soil+15% Concrete dust	Soil+20% Concrete dust	Soil+25% Concrete dust
1	15	15.39	14.87	13.5	12.59	10.92

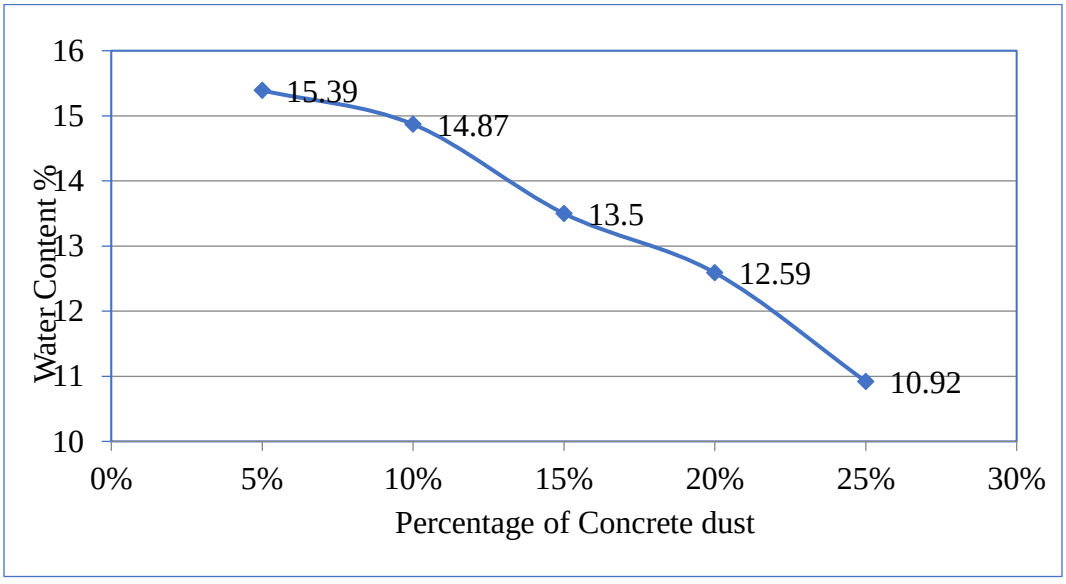

Fig. 6 Optimum moisture content at different percentage of Concrete dust

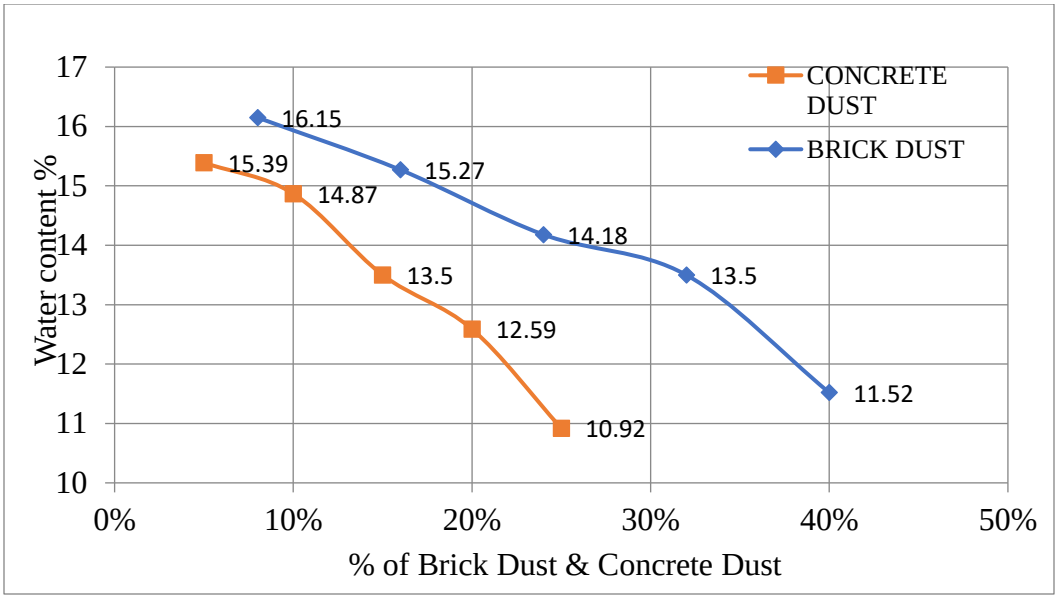

Fig. 7 Optimum moisture content at different percentage of Concrete dust & Brick dust

CBR value at different percentage of brick dust and Concrete dust

Table: 6 CBR Values at different percentage of Brick dust

Sl.No.	CBR Values Vs. % of Brick dust					
	Virgin soil	Soil+8% Brick dust	Soil+16% Brick dust	Soil+24% Brick dust	Soil+32% Brick dust	Soil+40% Brick dust
1	2.73	2.86	3.47	3.88	4.29	4.91

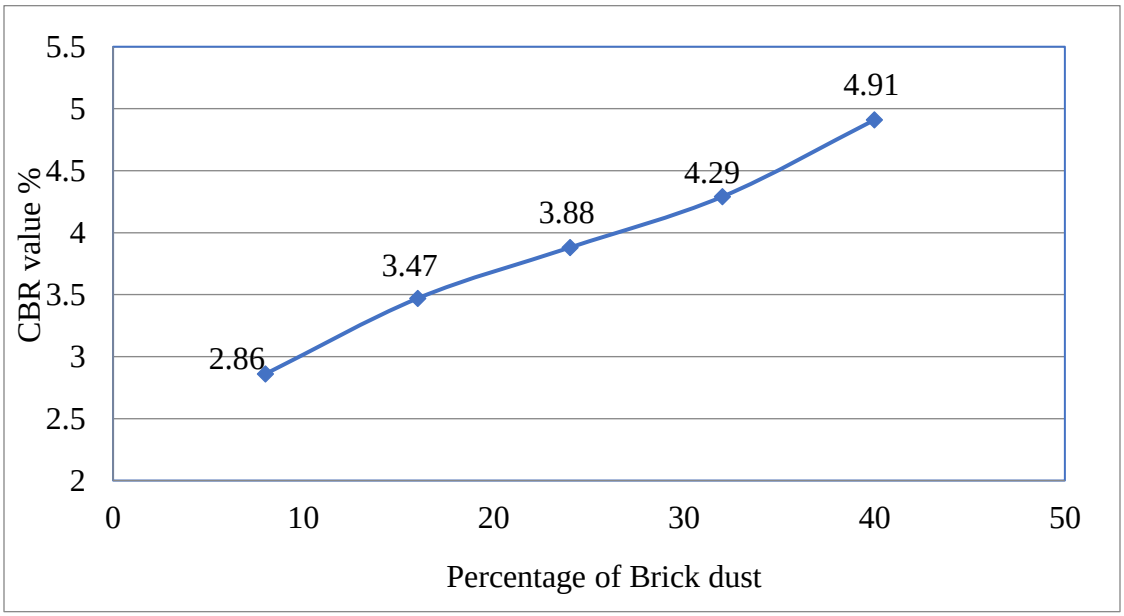

Fig. 8 CBR Value content at different percentage of Brick dust

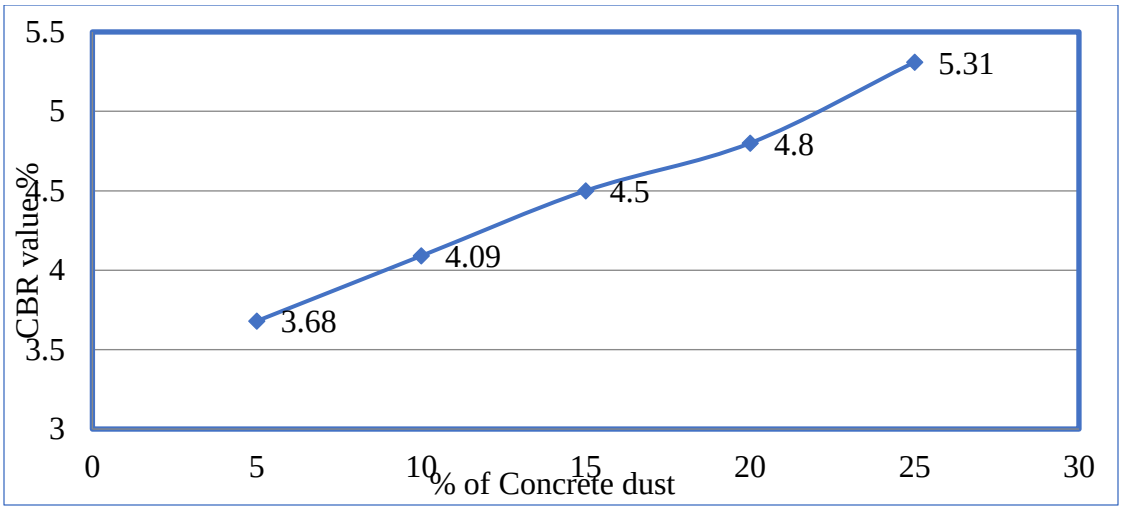

Fig. 9 CBR Value at different percentage of Concrete dust

Table: 7 CBR Values at different percentage of Concrete dust

Sl.No.	CBR Values Vs. % of Concrete dust					
	Virgin soil	Soil+5% Concrete dust	Soil+10% Concrete dust	Soil+15% Concrete dust	Soil+20% Concrete dust	Soil+25% Concrete dust
1	2.73	3.68	4.09	4.5	4.8	5.31

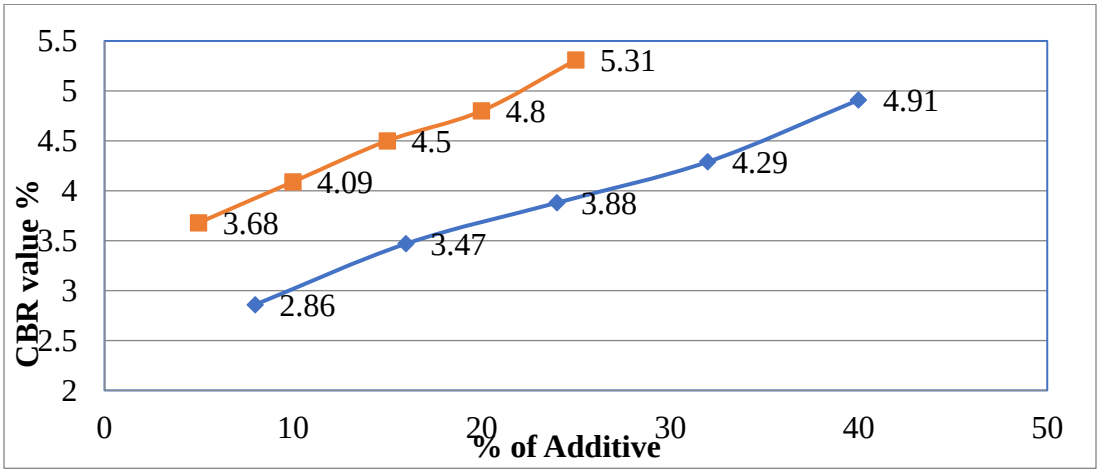

Fig. 10 CBR Value at different % of brick dust & concrete dust

UCS Values at different percentage of brick dust and concrete dust

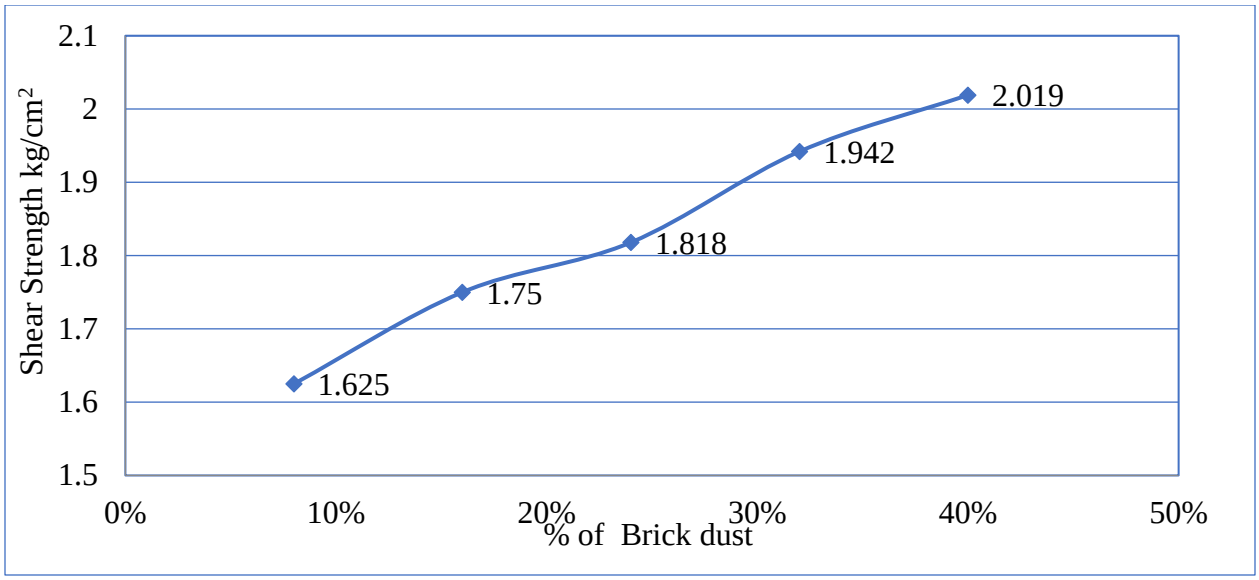

Fig. 11 Shear Strength at different % of brick dust

Table: 8 UCS Values at different percentage of brick dust

Sl.No.	Shear Strength Vs. % of Brick dust					
	Virgin soil	Soil+8% Brick dust	Soil+16% Brick dust	Soil+24% Brick dust	Soil+32% Brick dust	Soil+40% Brick dust
1	1.401	1.625	1.75	1.818	1.942	2.019

Table: 9 UCS Values at different percentage of Concrete dust

Sl.No.	Shear Strength vs. % of Concrete dust					
	Virgin soil	Soil+5% Concrete dust	Soil+10% Concrete dust	Soil+15% Concrete dust	Soil+20% Concrete dust	Soil+25% Concrete dust
1	1.401	1.844	1.901	1.953	2.036	2.131

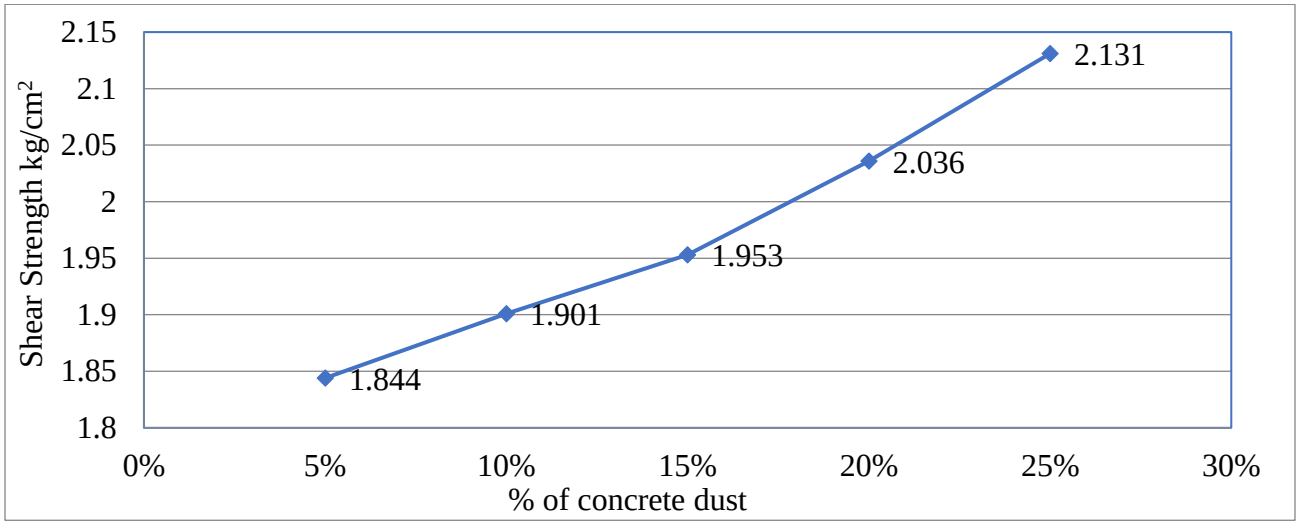

Fig.12 Shear Strength at different % of brick dust Concrete dust

CONCLUSION

The expansive soil can be well stabilized with construction and demolition waste as expansive soil converts to a well graded material on their addition. Based on the results obtained and comparisons made in the present study, the following conclusions can be drawn:

- The standard compaction parameters i.e. maximum dry density of expansive soil increases from 1.85g/cm to 1.96 g/cm and the optimum water content of expansive soil decreases from 15 % to 11.52 % when brick dust as a additive mixed into soil sample. (Fig.5.3)
- The standard compaction parameters i.e. maximum dry density of expansive soil increases from 1.85g/cm to 2 g/cm and the optimum water content of expansive soil decreases from 15 % to 10.92 % when concrete dust as a additive mixed into soil sample.(Fig.5.6)
- The result of CBR test when 40 % brick dust mixed in soil sample shows that the soaked CBR values of expansive soil increases to 2.73 and 4.91 respectively. (Fig.5.7)
- The result of CBR test when 25% concrete dust mixed in soil sample shows that the soaked CBR values of expansive soil increases to 2.73 and 5.31 respectively. (Fig.5.8)
- The result of UCS test when soil sample mixed with brick dust shows that unconfined compressive strength values of expansive soil increases from 1.401 Kg/cm2 to 2.019 Kg/cm2 (Fig.5.10)
- The result of UCS test when soil sample mixed with concrete dust shows that unconfined compressive strength values of expansive soil increases from 1.401 Kg/cm2 to 2.131 Kg/cm2 (Fig.5.11)
- The mineralogical composition of expansive soil and the final optimum mix were determined with the help of XRD techniques, which shows that the expansive soil having the Montmorillonite as a clay mineral which passage a swelling nature in soil but after stabilization the final optimum mix have not contain these mineral. Thus the various proportions of brick dust & concrete dust obtained from construction and demolition waste improving the strength of expansive soil. (Fig. 4.29, Fig. 4.44)

From the practical point of view, the stabilized expansive soil can be successfully used as an embankment and sub- grade material in flexible pavement design with cost effectiveness. Thus, the stabilization of locally available problematic soil with utilizing construction and demolition waste materials improved compaction and strength characteristics and reduces the cost of construction substantially. The degradation caused to the environment due to use of these waste materials can also be controlled to some extent.

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