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# Compaction Characteristics of Swelling Soil Stabilized with Bottom Ash and Geogrid

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**Abstract :** This paper brings out the results of experimental work carried out in the laboratory to evaluate the effectiveness of using bottom ash with geogrid for soil stabilization by studying the compaction and strength characteristics for use as a sub-grade material. Bottom ash is a waste material which is obtained from thermal power plants. This waste imposes hazardous effect on environment and human health. This material cannot be disposed of properly and their disposal is not economical. Utilization by exploiting their inherent properties is the one of the way to solve the above stated problem. The effect of mixing different proportions of bottom ash with geogrid in clayey soil on compaction, UCS and California bearing ratio have been studied in this study.

**Keywords :** Compaction. UCC, California bearing ratio, bottom ash, geogrid.

## Introduction

The black clay soil of this region has contributed to the Coimbatore's (Tamil Nadu, India) flourishing agriculture industry and it is in fact, the reason for the successful growth of cotton and served as a foundation for the establishment of its famous textile industry.

Structures which are built over the black cotton soil are prone to fail or damages due to low shear strength, swell and shrinkage are characteristics features (Sharma NK, 2011). Such soils are extensively found in and around Coimbatore for a considerable depth. This has resulted in the settlement of building, failure of pavement, bridges etc. On wetting, the black cotton soil becomes soft and exhibit very low shear strength and on drying the clay becomes hard and achieves very high shear strength (Pandian NS, 2004). These alternate changes should be controlled and the soil should be limited to certain shear strength. The soil stabilization along with soil reinforcement is taken into consideration for the study of the behavior of black cotton/expansive soil in Coimbatore. Recent trend in research works in the field of geotechnical engineering and construction materials focuses more on the search for cheap and locally available materials such as industrial wastes as stabilizing

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agents (T. Taskiran, 2010). These wastes can be treated as replacement for traditional stabilizers. Industrial waste is increasingly becoming a focus for researchers because of the enhanced pozzolanic capabilities of such wastes when oxidized by burning (Jyoti S.Trivedia, et al.,2013,). Thus, this study aims at evaluating the possibility of utilizing industrial wastes such as bottom ash in the stabilization of black cotton soil in Coimbatore (Taskiran 2010,Trivedia et al 2013, Mukesh A. patel, HS Patel, 2013,BIS 2720) .

## Material and Methods

### Methodology

Methodology mainly consists of three parts. Part 1 includes identification of problems in construction of roads in black cotton soil, review of literatures and collection of clay, bottom ash and geogrids. Part 2 and part 3 are laboratory works which are mainly focused on determination of index and engineering properties of soil with geogrid and bottom ash mixture (Taskiran 2010,Trivedia et al 2013, Mukesh A. patel, HS Patel, 2013,BIS 2720).

### Materials

#### Collection of Clay

Clay for this research work is collected from Vadavalli, Coimbatore, Tamilnadu state, India. The locations are 11.0247° N, 76.8980° E. The soil sample was present at depth of 5 feet from ground level.

#### Bottom ash and Geogrid

Industrial waste such as bottom ash (Figure 1) was collected from Mettur Thermal Power Station at Mettur and Geogrid (Figure 2) was collected from IVRCL private limited at Avinashi highway project, Avinashi.



Fig.1 Bottom ash

Fig.2 Geo grid

### Mineral Composition of Cement Kiln Dust

Mineral Composition of bottom ash were obtained from PSG College of Technology, Coimbatore by conducting EDAX/SEM tests and recorded in table.1

Table.1 Mineral composition of Bottom ash

Mineral Composition	Bottom ash (%)
Silica (SiO <sub>2</sub> )	50.52
Alumina (Al <sub>2</sub> O <sub>3</sub> )	24.41
Calcium Oxide(CaO)	2.42
Magnesium Oxide (MgO)	1.58
Potassium Oxide (K <sub>2</sub> O)	1.03
Loss of Ignition(LOI)	18.96
Phosphorous (P <sub>2</sub> O <sub>5</sub> )	0.48

### Laboratory Investigation

Laboratory experimentations for determining various properties (Table.3) for soil stabilization with bottom ash and geogrid have been carried out with the necessary test procedure as per the requirements of BIS standards. The details of referred standards for performing various index and geotechnical tests with selected soil, bottom ash and geogrid and soil stabilization with bottom ash and geogrid has been listed in Table below (Table.2) (Taskiran 2010,Trivedia et al 2013, Mukesh A. patel, HS Patel, 2013,BIS 2720).

**Table.2 Test Procedure followed from BIS Standards**

Test / Property / Procedure	BIS code / Reference Standard
Soil Classification	IS :1498: 1970
Particle Size distribution including Hydrometer Analysis	IS 2720: Part 4: 1985
Specific Gravity	IS 2720: Part III/Section 2: 1980
OMC & MDD (Standard Proctor compaction)	IS 2720: Part 7 :1983
Liquid Limit	IS 2720: Part 5: 1985
Plastic Limit	IS 2720: Part 5 : 1985
Unconfined Compressive Strength	IS 2720: Part 10 :1991
Soaked and Unsoaked CBR	IS 2720: Part 16:1987 IS 2720: Part 31:1990 IRC :37: 2001 IRC :33: 1969

**Table.2 Properties of Clay**

Properties	Results
Initial Moisture Content %	11.29
Specific Gravity	2.70
Sieve Analysis	
% of Gravel	0
% of sand	25.25
% of Silt	21.39
% of Clay	54.36
Free Swell Index %	60
Swell pressure (kpa)	38.8
Liquid Limit ( $W_L$ ) %	61.09
Plastic Limit ( $W_P$ ) %	26.04
Shrinkage Limit ( $W_S$ ) %	22.19
Plasticity Index ( $I_P$ ) %	35.05
Soil Classification	CH
OMC (%)	24.83
MDD g/cc	1.52
UCC Strength ( $q_u$ ) kN/m <sup>2</sup>	126.01
Cohesion ( $C_u$ ) kN/m <sup>2</sup>	63.01
CBR unsoaked (%)	4.0
CBR soaked (%)	1.9

### Experimental Study

Experimental study explains the various index and engineering properties of soil- bottom ash mixtures such as natural moisture content, specific gravity, liquid limit, plastic limit, shrinkage limit, particle size distribution, Optimum Moisture Content, Maximum Dry Density, Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR), free swell Index etc. The properties of virgin soil are given in table.2 for the purpose of reference, which are being determined during this investigation (Taskiran 2010,Trivedia et al 2013, Mukesh A. patel, HS Patel, 2013,BIS 2720) .

### Compaction Test

Standard proctor compaction test was performed on the soil sample mixed with varying amount of bottom ash such as 5%, 10%, 15%, 20%, 25% and 30%. From this test the compaction characteristics of the soil samples were studied by determining OMC and MDD respectively (Figure.3)(BIS 2720).



Figure 3. Automatic compaction machine

### Unconfined Compressive Strength Test

Unconfined compression test is conducted in order to determine the Unconfined Compressive Strength and cohesion of samples with bottom ash in varying proportions of 5%, 10%, 15%, 20%, 25% and 30%. All the samples are compacted at its optimum moisture content (Figure.4-7) (BIS 2720). The UCS test results are shown in Figure 5-7.



Figure.4 UCC test apparatus with specimen

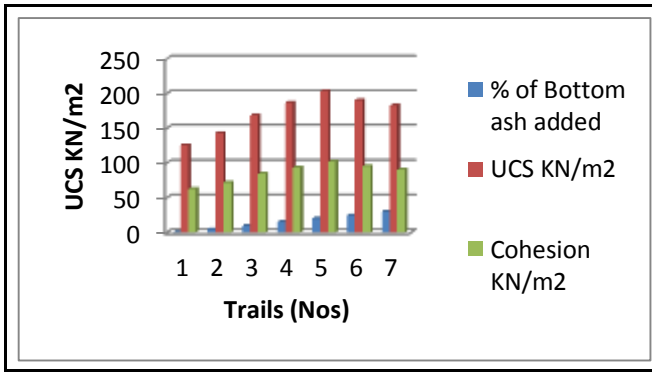


Figure.5 UCS of clay stabilized with bottom ash

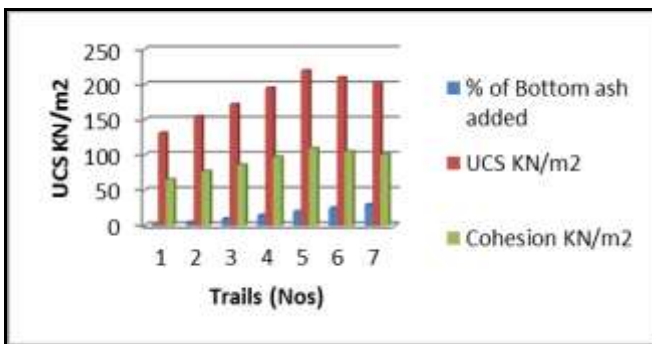


Figure.6 UCS of clay stabilized with bottom ash and single layer of geogrid

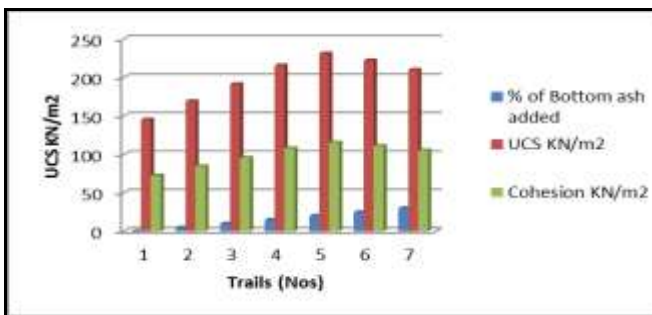


Figure.7 UCS of clay stabilized with bottom ash and double layer of geogrid

### California Bearing Ratio Test

For any pavement design, CBR is the prime factor which determines the thickness of each pavement layer. Unsoaked and soaked California Bearing Ratio Tests are conducted on soil samples prepared under its optimum moisture content under unsoaked and soaked condition to determine the CBR value of soil with varying percentage of bottom ash content. The test is conducted on soil samples with 5%, 10%, 15%, 20%, 25% and 30% to determine the optimum bottom ash content. The Load Vs Penetration curves obtained from the tests (Figure.8) (BIS 2720).



Figure.8 CBR Test with compacted sample

## Conclusions

Based on the experimental investigations on stabilization of clay, the following conclusions are drawn.

1. The initial laboratory investigations showed that collected clay soil sample is solid, stiff and has high compressibility.
2. The optimum percentage replacement of bottom ash is found to be 20% with double layer of geogrid.
3. The results improved at 20% replacement are as follows – The liquid limit, plasticity index decreases and maximum dry density shows a significant change.
4. The optimum moisture content increases with increase in bottom ash replacement.
5. The unconfined compressive strength of untreated soil is 126.01 KN/m<sup>2</sup>. The addition of bottom ash has increased the UCC strength to 231.31 KN/m<sup>2</sup> at 20% bottom ash with double layer of geogrid.
6. The blend suggested from this investigation is clay with 20% replacement by bottom ash with double layer of geogrid, would be an economical approach.
7. Furthermore if the soil reinforcement is provided, there will be more perfection in properties of expansive soil.

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