A STUDY ON EFFECTS OF SATURATION ON SOIL SUBGRADE STRENGTH BY UTILIZATION OF INDUSTRIAL AGRICULTARAL WASTE IN SUB-GRADE LAYER

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ABSTRACT :- Design of pavement depends on the strength of subgrade soil. Subgrade strength is determined by CBR (California Bearing Ratio) and the results are expressed as CBR value in percentage. The strength of soil can be improved by suitably adding stabilizing agent resulting in reduction of the thickness of the layer. Engineering properties of selected samples such as unconfined compressive strength, proctor density with corresponding optimum moisture content and California Bearing Ratio were studied for the untreated samples of soil. Coal ash was added as stabilizing agent on 0%, 10%, 20%, 30%, 40%, 50% and 60%, whereas bagasse ash and groundnut shell ash was added as stabilizing agent with 0%, 2%, 4%, 6%, 8%, 10% and 12%.

Design of flexible pavement have been taken into considerations as per IRC 37:2012. For all ten samples, pavement sections for optimum combinations of coal ash, bagasse ash, groundnut shell ash and geosynthetics reinforcement along with layer combinations put together 100 combinations have been obtained for pavement response analysis. With the help of IITPAVE software pavement response studies have been performed for rutting and fatigue criteria. IITPAVE is based on multilayer elastic approach. Considerable reduction in vertical compressive strain (rutting criteria) on top of subgrade and horizontal tensile strain (fatigue criteria) at the bottom of bituminous layer of the pavement is observed in pavement response analysis studies.

Key words:-Bhagsse ash, Ground nut shell, soked CBR,unsoakedCBR,
Flexible pavement.

I INTRODUCTION

Disposed coal ash is a result from the residue of coal refinery processes and has become an environmental important issue. Coal ash consists of bottom ash (5-15%) and fly ash (85-95%). In engineering practice, utilization of coal ash is limited and in small quantity, while the disposal of coal ash is quite high. In our country, there are about 130 thermal power plants, producing around 100 million tones of fly ash as waste material. Since the fly ash has pozzolanic property, it can be utilized as an alternative cementitious material in civil engineering applications. The disposal problem of fly ash can be avoided up to certain extent by using it for the construction of roads, airfields, and embankments and in fly ash brick industry etc. Sugarcane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapour. This waste product causes serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminium ion and silica. Groundnut shell is an agricultural waste obtained from milling of groundnut. The ash from groundnut shell has been categorized under pozzolana. The utilization of this pozzolana as a replacement for traditional stabilizers will go a long way in actualizing the dreams of most developing countries of scouting for cheap and readily available construction materials. Groundnut shell ash has been used in concrete as a partial replacement material for cement with a measure of success achieved (Jaganatha Rao & Jai Bagwan 2001, Bhuvaneshwari et al. 2005, Ahmad rifa'i et al. 2009,

Aigbodion et al. 2010, Kumar et al. 2010, Amu et al. 2011). Problematic soils such as expansive soils are normally encountered in foundation engineering designs for highways, embankments, retaining walls, backfills, etc. Expansive soils are normally found in semi-arid regions of tropical and tem- perate climatic zones and are abundant, where the annual evaporation exceeds the precipitation and can be found any- where in the world. Expansive soils are also referred to as "black cotton soil" in some parts of the world. They are so named because of their suitability for growing cotton. Black cotton soils have varying colours, ranging from light grey to dark grey and black. The mineralogy of this soil is dominated by the presence of mont morillonite which is characterized by large volume change from wet to dry seasons and vice versa. Deposits of black cotton soil in the field show a general pattern of cracks during the dry season of the year. Cracks measuring 70 mm wide and over 1 m deep have been observed and may extend up to 3m or more in case of high deposits. The three most commonly used traditional stabilizer for expansive clays are bitumen, lime and cement. A 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 and agricultural wastes, etc. as stabilizing agents for the purpose of full or partial replacement of traditional stabilizers.

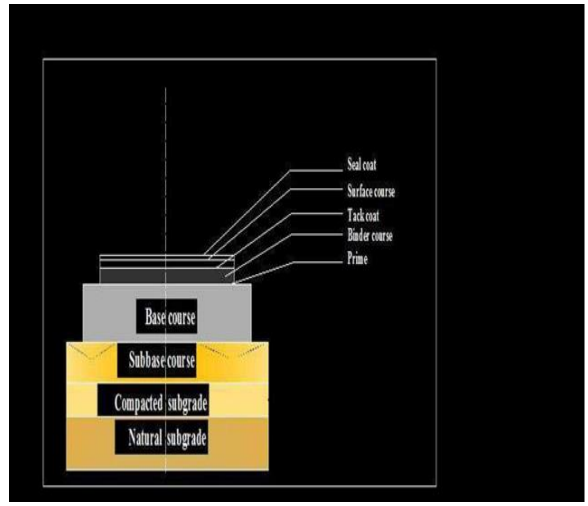

Figure -1 Flexible Pavement Structure

The objectives of the present investigation are

- To study the behaviour and effect of Industrial and Agricultural wastes such as Coal ash, Bagasse ash and Groundnut shell ash in the stabilization of expansive soil used as subgrade pavement.
- To study the physical, chemical and engineering properties of soil stabilized with waste materials mixture by conducting laboratory and experimental tests.
- To study the chemical properties of soil samples stabilized with waste materials mixture by conducting chemical tests such as PH, total solids, sulphates, carbonates, sulphides, chlorides. etc
- To find out the stabilizing potential of coal ash, groundnut shell ash and bagasse ash in highly expansive soil with and without geogrid reinforcement and to find out the optimum strength parameters.
- To perform Cost analysis to study the cost variations of pavement laying system.

Table 3.1 Mineral composition of coal ash

Mineral Composition	Bottom ash (%)	Fly ash(%)
Silica (SiO_2)	33.25	50.40
Alumina (Al_2O_3)	21.41	16.57
Calcium Oxide(CaO)	30.37	7.95
Magnesium Oxide (MgO)	6.44	6.07
Potassium Oxide (K_2O)	2.78	4.51
Loss of Ignition(LOI)	1.10	1.17
Phosphorous (P_2O_5)	1.32	1.31

Table 3.2 Mineral Composition of Bagasse ash

Mineral Composition	Bagasse ash(%)
Silica (SiO_2)	76.34
Alumina (Al_2O_3)	10.55
Iron Oxide (Fe_2O_3)	3.61
Calcium Oxide(CaO)	2.15
Manganese Oxide (MnO)	0.13
Potassium Oxide (K_2O)	3.46
Sodium Oxide (Na_2O)	0.12
Titanium Oxide (TiO_2)	0.50
Loss of Ignition(LOI)	0.42
Phosphorous (P_2O_5)	1.07
Barrium Oxide (BaO)	0.16

Methodology

The present study is mainly focused on experimental and artificial neural network and multiple regression investigations for soil subgrade strength improvement. Experimental investigation methodology has been adopted for assessing the effect of coal ash, bagasse ash, groundnut shell ash stabilization on selected subgrade soils. Laboratory experimentations necessary for the present study have been carried out as per the guidelines and procedures specified by Indian standards as and when appropriate. IRC recommendations have been taken into considerations for the design of pavement configurations based on compacted subgrade with coal ash, bagasse ash, Groundnut shell ash and geosynthetics.

Laboratory Test Methods Adopted

Laboratory experimentations for determining various properties for soil stabilization with Coal ash, Bagasse ash, Groundnut shell ash and geosynthetics have been carried out with the necessary test procedure as per the requirements of BIS standards. The details of referred standards and test procedures for performing various index and geotechnical tests with selected ten types of soils, Coal ash, Bagasse ash, Groundnut hell ash and geosynthetics and soil stabilization with coal ash, bagasse ash, groundnut shell ash and geosynthetics

Tests on materials: Laboratory tests were conducted in the geotechnical laboratory for the collected soil samples to clas- sify the soil, evaluate its physical and engineering proper- ties and to study the compaction characteristics. Proctor's Compaction tests, UCC tests, and CBR (unsoaked and soaked) tests were conducted on samples with 0%, 10%, 20%, 30% of CA, 0%, 4%, 8%, 12% of BA, 0%, 4%, 8%, 12% of GSA contents and 0%, 4%, 8%, 12%, 16%, 20% of CA+BA, CA+GSA, BA+GSA contents. All the tests were conducted on samples prepared under both light and heavy energy of compaction. The standard Proctor's compaction tests were conducted on the soil samples to evaluate the optimum moisture content and maximum dry unit weight of samples. UCC tests were conducted on soil samples to determine the UCC strength and cohesion. Results obtained were compared and conclusions were made based on the results obtained.

RESULTS AND DISCUSSION:

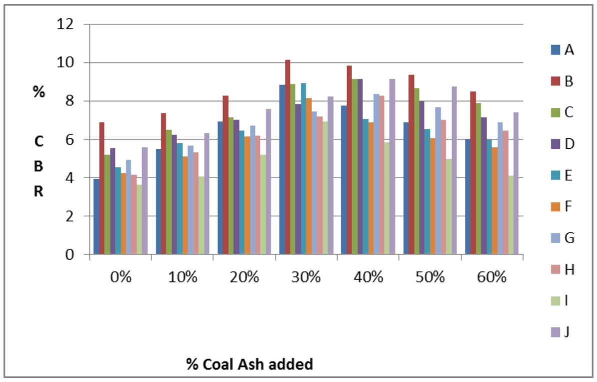

Figure 2 CBR for unsoked % of coal ash added to soil

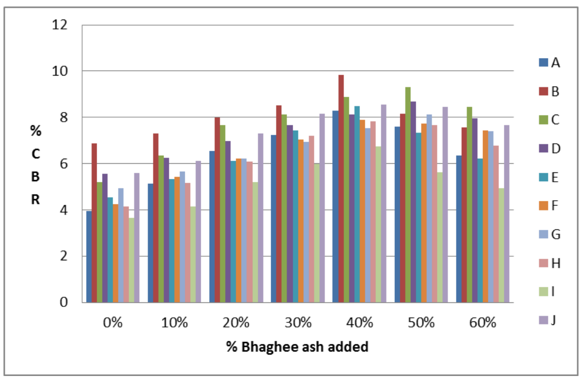

Figure 3 CBR for unsoked % of Bhaghee ash added to soil

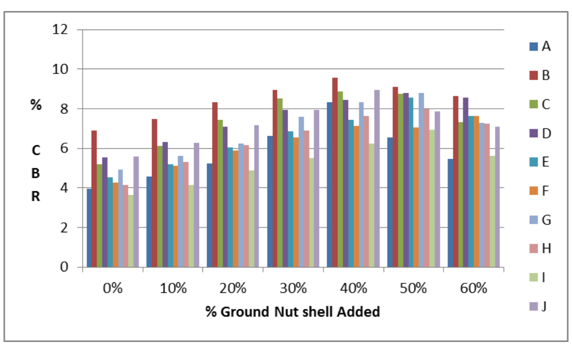

Figure 4 CBR for unsoked %of Ground nut sheel added to soil

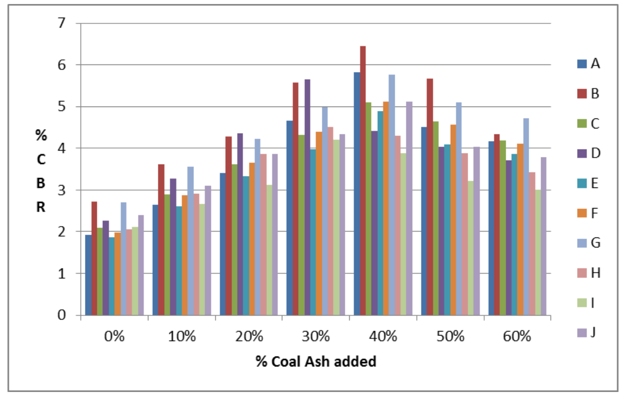

Figure 5 CBR for soked %of Ground nut sheel added to soil

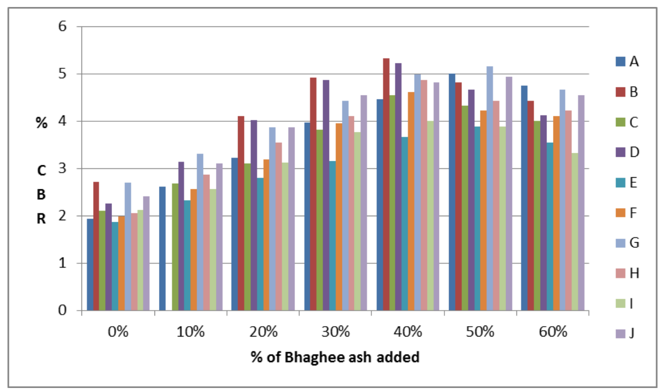

Figure 6 CBR for soked %of Ground nut sheel added to soil

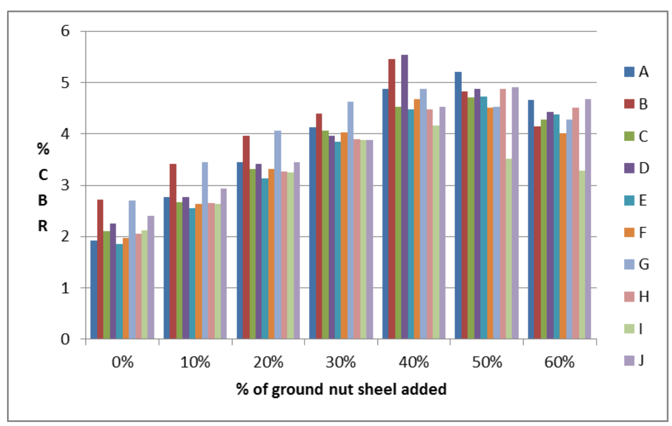

Figure 7 CBR for soked %of Ground nut sheel added to soil

CONCLUSION:

The reactions behind the variations in CBR values with the addition of coal ash, bagasse ash and groundnut shell ash are the same as that of the variations in UCC strength. The increases in CBR values with the inclusion of geogrid are mainly due to the reinforcing effects of geogrid. Lateral restraint and tensioned membrane effects of geogrid contribute to the increase in CBR.

The investigations with coal ash, bagasse ash and groundnut shell ash stabilization reported considerable improvement in unsoaked and soaked CBR of all the soils under study. The improvement in soaked CBR is important for enhanced bearing capacity of subgrade soil. The increase in soaked CBR of subgrade is advantageous in design of flexible pavement section. The increase in soaked CBR of CH and Cl soils is due to the addition of ashes, reduction in plasticity of these soils, reduction in voids ratio due to stabilization with ashes, and increase in di-calcium silicates and tri-calcium aluminates are as a result of stabilization.

- Replacement of clay soil with ashes results in modified textural and structural properties of the all CH and CI soils.
- With the increase in percentage of Coal ash, Bagasse ash and Groundnut shell ash in soil, the percentage of swelling has decreased. It is evident from the decrease of the liquid limit, plasticity index, free swell index and swell pressure.
- Coal ash and Groundnut shell ash stabilization decreases the OMC of CH and CI soils whereas, Bagasse ash stabilization shows an increase in OMC.
- MDD of all the ten soil types decreases due to stabilization by coal ash, bagasse ash and groundnut shell ash.
- Coal ash, bagasse ash and groundnut shell ash stabilization decreases the liquid limit and plastic limit of all CH and CI soils whereas PI of these soils also reduces in all cases. The reduced PI has been found to be beneficial for improving the soaked CBR value of the soils. Modifications in plasticity enhanced the soaked CBR value of these soils.

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