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Study on Index Properties of Expansive Soil Mixed With Rice Husk Ash and Fly Ash

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Abstract - *The accessible soil in various locations may not be suitable as a construction material and supporting material for large multi-story houses, highway constructions, or as a filling material due to its higher compressibility and low bearing ability. Since good soil is expensive and increases project costs, it cannot be replaced anywhere. This dilemma can be solved by improving the properties of the soil that will be used in infrastructure projects. Many studies have been conducted to use waste materials to boost soil properties and to use waste materials in a more environmentally friendly manner. Industrial waste, such as rice husk ash and fly ash, may be used to enhance this soil. Industrial wastes face significant storage, space, and land constraints, making disposal prohibitively costly. As a result, agricultural waste such as rice husk ash, fly ash, and used tyres can be used as a replacement material by combining them with sand, cement, and lime in a specific proportion. The aim of this paper is to improve expansive soil as a building material by using waste materials such as rice husk ash (RHA) and fly ash. Soil is an unusual substance. Some waste products, such as Fly Ash, rice husk ash, and pond ash, may be used to stabilize the soil. The addition of such materials would improve the soil's physical and chemical properties. shear strength, liquidity index, plasticity index, unconfined compressive strength, and bearing ability are some of the properties that are expected to increase. The aim of this research was to see how Fly Ash and Rice Husk Ash affected the output of black cotton soil. In this paper, black cotton soil is treated with fly ash (5 percent, 10%, 15%,) and rice husk ash (10 percent, 15%, 20%), and the results are examined after 28 days of curing.*

***Key Words*: Higher Compressibility, Poor Bearing Capacity, Fly Ash, Rice Husk Ash and Expansive Soil.**

1. INTRODUCTION

Clays generally have undesirable engineering properties. Soil can be considered as an ancillary material obtained from a geological cycle vise that continues continuously in nature. Compacted soil is used in several examples of geotechnical structures and engineering structures, such as road embankments, earth dams, highway and runway basements, terrain barriers and many other structures. Soil compaction is usually done to reduce permeability and increase the characteristic soil resistance, which increases the bearing capacity of the foundations built on top of it. In India, most of India's black cotton soils occupy an estimated area of 74 million hectares. These soils are generally found in Maharashtra, western Madhya Pradesh, Gujarat and parts of Andhra Pradesh, Tamil Nadu, etc. Disposal of solid waste in the landfill can be minimized if the waste has desirable properties they can therefore be used for various geotechnical applications. The goal of soil remediation is to increase strength, reduce deformability, stabilize volume, reduce permeability, minimize erodibility, improve durability and control variability. The use of waste helps to solve a double problem first of all a problem of disposal of waste and secondly leading to an improvement of soil properties with economy. A review of the literature indicates that industrial waste can be used in soil improvement. Industrial wastes such as fly ash, rice husk ash, especially those with pozzolanic properties are useful in this regard in the present study two industrial waste fly ash from the kothagudam thermal power plant and rice husk ash.

According to Geo technology, soil improvement can either be by modification or by stabilization, or by both. Soil modification is the process of addition of a modifier (cement, lime, etc.) to the soil to change its index properties, while soil stabilization is the treatment of soils to increase their strength and durability so that they are suitable for construction beyond their original classification. In most of the situations, soils in natural state do not possess proper geotechnical properties to be used as road service layers, foundation layers and as a construction material. In order to make them useful and meet the requirements of geotechnical engineering design, researchers have concentrated more on the use of cost effective materials that are available locally from industrial and agricultural wastes in order to increase the properties of deficient soils and also to reduce the cost of construction. Due to the large production of agricultural wastes, the world is facing a serious problem of its handling and disposal. The disposal of agricultural wastes has a potential negative impact on the environment causing air pollution, water pollution and finally affecting the local ecosystems. Hence the secure disposition of agricultural wastes has become a challenging task for engineers. The main aim of the paper is to investigate the use of Rice husk ash (RHA) which is an agricultural waste to stabilize the weak sub grade soil. This hitherto have continued to impede the poor and under developed nations of the world from providing accessible roads to their rural inhabitants who contribute to the major percentage of their population and are mostly, agriculturally dependent. Thus by using the agricultural waste (such as rice husk ash – RHA, Fly-ash) the cost of construction will be considerably reduced as well reducing the environmental hazards they cause. It has been identified by Sear (2005) that Portland cement, with respect to its chemistry, produces large amounts of CO 2 for each ton of its final product. Hence by replacing proportions of the Portland cement with a secondary cementitious material like RHA and Fly-ash in soil stabilization will reduce the overall negative environmental impact of the stabilization process.

2. LITERATURE REVIEW

- **P. Chritz** Suggested about performance evaluation of mixed in place bituminous stabilized assume gravel. Here it was showed an cheap maintenance of gravel shoulders, a very common problem is facing by highway agencies.
- **Hussain** carried out an brilliant work to establish the link between CBR value and undrained shear strength value from Vane Shear Test. It was exposed that un-drained shear strength value and CBR value increased with increasing plasticity index. In decision it was achieved that shear strength and CBR value is inversely proportional to the water content of that material.
- **Martinet al.** established a paper deals with foam bitumen stabilization. Foamed bitumen is a combination of bitumen, air and water. Here 2.5 percent of cement and 3.5 percent of bitumen foam was used. From here it has been found that Analysis using foamed bitumen had proved to be successful because of its ease and speed of construction, its compatibility with a extensive range of aggregate types and its relative resistance to the effects of climate
- **Michael** had suggested about Bench-Scale Evaluation of Asphalt Emulsion Stabilization of Dirtied Soils. In this study, it was conversed about the use are discussed to the environmental fixation of soils contaminated by organic contaminants.
- **Razouki et al.** gives an experimental study on Gravelly Stabilized Roads. Bitumen was used as a stabilizing agent act as a binder or as a water-proofing material. Soilbitumen systems had found the highest used in road bases and surfaces.
- **Cokca et al.** concentrated on the effects of compaction dampness content on the shear quality of an unsaturated sludge. The effects of compaction dampness substance and soaking on the unsaturated shear quality parameters of sludge were examined. Experiments were carried out on varieties compacted at optimum dampness content, on the dry side of optimum and on the wet side. It was found that edge of corrosion reductions quickly with increasing dampness substance, the union segment of shear quality attained its top rate at around optimum Moisture substance and subsequently diminishes.
- **Perkins and Madson** proposed an approach based on relative density for shallow foundations on sand and described the effect of progressive failure on ultimate bearing capacity in terms of the relative dilatancy index inherent in strength-dilatancy relationships. Competing with the notion of progressive failure offered by Yamaguchi et al (1977) [38], the authors observed from the shear tests that the potential for progressive failure is more acute for low confinement conditions or for smaller footing widths and stated that two counteracting mechanisms occur: (i) The physical observation that progressive failure, being defined in terms of the nonuniformity of shear strain and mobilised friction angle in the soil at peak footing load, is more significant as footing width increases, and (ii) the potential for progressive failure, being defined by the difference between the peak and residual strength of the soil, is more significant as the footing width decreases. The authors have postulated that the combination of these two effects can be described in terms of strength-dilatancy characteristics of the soil, which are dictated by the soil type, relative density and footing geometry.
- **Keshavarz and Kumar (2017)** have numerically evaluated ultimate bearing capacity of circular and strip footings, placed over rock mass using the method of stress characteristics for both smooth and rough footing-rock interface. The modified HB failure criterion was used in the analysis. The bearing capacity has been presented in the form of nondimensional bearing capacity factors as a function of different input parameters for rock mass. The authors have noted that an increase of GSI and mi leads to an increase in the values of Nσ and Nσ0 and that the factor Nσ has been found to increase continuously with a decrease in the value of σc/(γb). The roughness of the footing has been found to have more significant effect for a circular footing as compared with a strip footing. The results obtained from the present study have been found to compare quite well with the different solutions available from literature.

3. MATERIALS AND METODOLOGY

3.1 Black Cotton Soil

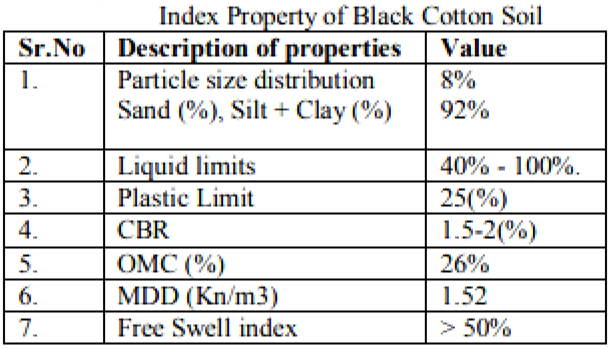
It is collected from outskirts of Vijayawada Andhra Pradesh from ground having coordinates 16.52°N latitude 80.62°E longitude. Soil sample is collected from location of above site. Soil Sample is collected 1 meter below the original depth then collected into bag and send into the laboratory for examination.

Fig-1 Collection of Specimen and Testing

3.2 Rice Husk Ash

The rice husk ash was collected from Kamakshi rice mills Chennai, Tamil Nadu. In the form of ash which is a solid wasted which is disposed in the empty barren land as a solid waste. Rice Husk Ash is byproduct material produced from the process of manufacturing puffed rice, contains large amount of iron oxide and silicate. It has higher density, stay in the top layer and then transported to a water basin with a low temperature for solidification.

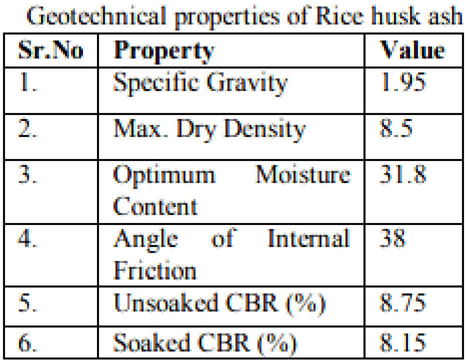
Properties of black cotton soil define as per BIS standards and properties of black cotton soil, Rice husk ash and fly ash are tabulated in below tables



Index Property of Black Cotton Soil

Sr.No	Description of properties	Value
1.	Particle size distribution Sand (%), Silt + Clay (%)	8% 92%
2.	Liquid limits	40% - 100%.
3.	Plastic Limit	25(%)
4.	CBR	1.5-2(%)
5.	OMC (%)	26%
6.	MDD (Kn/m3)	1.52
7.	Free Swell index	> 50%

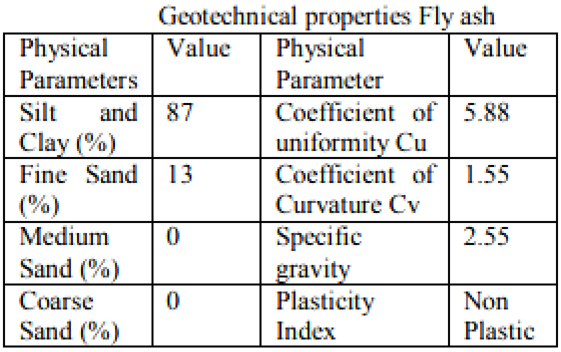
Table-1 Properties of Black cotton soil



Geotechnical properties of Rice husk ash

Sr.No	Property	Value
1.	Specific Gravity	1.95
2.	Max. Dry Density	8.5
3.	Optimum Moisture Content	31.8
4.	Angle of Internal Friction	38
5.	Unsoaked CBR (%)	8.75
6.	Soaked CBR (%)	8.15

Table-2 Properties of Rice husk Ash



Geotechnical properties Fly ash

Physical Parameters	Value	Physical Parameter	Value
Silt and Clay (%)	87	Coefficient of uniformity Cu	5.88
Fine Sand (%)	13	Coefficient of Curvature Cv	1.55
Medium Sand (%)	0	Specific gravity	2.55
Coarse Sand (%)	0	Plasticity Index	Non Plastic

Table-3 Properties of Fly Ash

3.3 Methodology

The soil is collected from different location at Vijayawada and collects into bags and sends in laboratory for examination. First Index property of soil is determined after then fly ash and rice husk ash mix in different proportions in soil and put into 28 days for curing. Total five combinations are formed and atterberg limit are evaluated in laboratory. The process of coal combustion results in fly ash. The major constituents of most of the fly ashes are Silica ($SiO2$), aluminaAl2O3), ferric oxide ($Fe2O3$) and calcium oxide (CaO). The other minor constituent of the fly ash are MgO, Na2O, K2O, SO3, MnO, TiO2 and un-burnt carbon. There is wide range of variation in the principal constituents - Silica (25-60%), Alumina (10-30%) and ferric oxide (5- 25%). When the sum of these three principal constituents is 70% or more and reactive calcium oxides less than 10% - technically the fly ash is considered as or class F fly ash. It has a long history of use as an engineering material and has been successfully employed in geotechnical applications. The effect on parameters like free swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and hydraulic conductivity of expansive soil was studied.

3.4 Laboratory Test

The designations for mixture soil and soil are detailed in Table 3.5 the soils are modified by using fly ash and rice husk Ash. Soil is modified by using fly ash and rice husk ash in the range of 0-25%. Table-1 shows details of soil mix and Symbols used for them.

Designations	Proportion
Soil only	100
Soil + 10%RHA	90:10
Soil + 15%RHA	85:15
Soil + 20% RHA	80:20
Soil + 10%RHA +5%FA	85:10:5
Soil + 15%RHA + 10%FA	75:15:10
Soil + 20%RHA +15%FA	65:20:15

Table-4 Different Proportions of Soil RHA and FA

3.5 Experimental Results

A few particular laboratory tests to determine the properties of the collected soil sample were undertaken for experimental evaluation. The grain size distribution curve for the soil sample was obtained for the purpose of appropriate classification of the soil. Thereafter the following experimental determination was made

Grain size distribution determination: This test was conducted on Soil only. It was found according to the procedure of the IS: 2720 (part 4)-1985. The graph between the particle size and Cumulative percentage finer as shown in Fig-1..It was found that the soil retained on IS: 4.75mm more than 50% and the finer soil is lesser, it can be considered that the soil is coarse grained soil. The soil sample is collected from a depth of 2m and is disturbed sample.

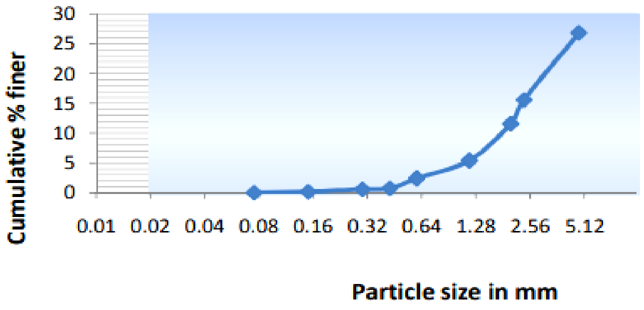


Fig-2 The graph between the Cumulative percentage finer (%) and particle size (mm)

Moisture content determination:

This test was conducted on Soil only, Soil + 10%RHA, Soil + 15%RHA, Soil + 20% RHA, Soil + 10%RHA +5%FA , Soil + 15%RHA + 10%FA, Soil + 20%RHA +15%FA.

It was as per the procedure of the IS: 2720 (part 2)-1973.

Plastic limit and liquid limit determination:

This test was conducted on the same sample proportional as mentioned above according to the procedure of the IS: 2720 (part 5)-1985.

Standard proctor determination:

It was found according to the procedure of the IS: 2720 (part 7)-1965.

Direct shear stress determination:

It was found to the procedure of the IS: 2720 (part 13)-1986.

4. RESULTS AND DISCUSSIONS

4.1 Consistency limits and Plasticity index

Mix proportion	Moisture content (%)	Dry density (g/cm3)	Liquid limit (%)	Plastic index (%)
Soil only	16	17.07	50	48.62
	11	18.42	66.66	
	21	16.77	58.33	
Soil + 10%RHA	8.69	13.33	25	20.54
Soil + 15%RHA	3.52	14.9	36.9	
Soil + 20% RHA	12.14	12	19.33	
Soil + 10%RHA+5%FA	10.7	19.04	31.75	7.65
Soil + 15%RHA +10%FA	5.9	26	43.66	
Soil + 20%RHA +15%FA	13.9	22	27.3	

Table-4: Consistency limits and Plasticity index

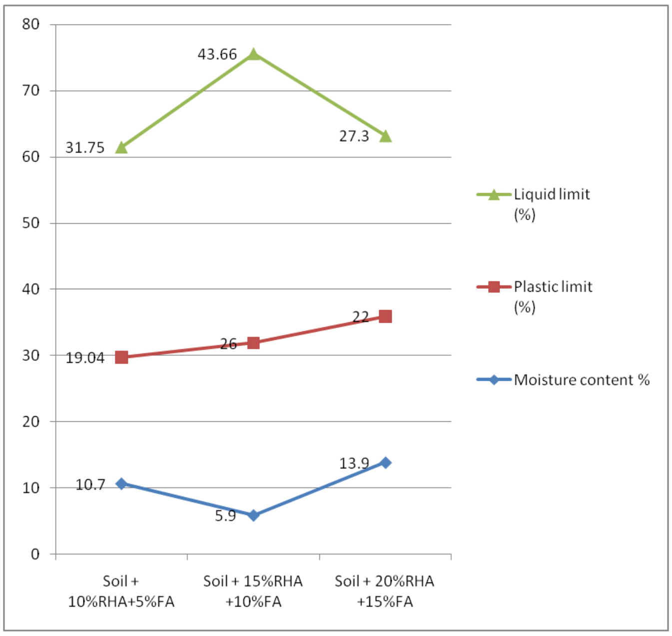


Fig-3 Graph shows the Liquid Limit, Plastic Limit and Moisture content of Different mixes

4.2 Proctor Test Results

Mix proportion	Moisture content (%)	Dry density (g/cm³)	OMC (%)	MDD (g/cm³)
Soil only	0.46	1.85	0.68	2.11
	0.67	2.11		
	1.11	2.08		
Soil + 10%RHA	1.65	1.86	1.65	1.86
Soil + 15%RHA	1.73	0.9		
Soil + 20% RHA	1.35	0.8		
Soil + 10%RHA+5%FA	5	1.74	1.92	3.43
Soil + 15%RHA +10%FA	3.43	1.92		
Soil + 20%RHA +15%FA	6	0.85		

Table-5 Proctor Test Results

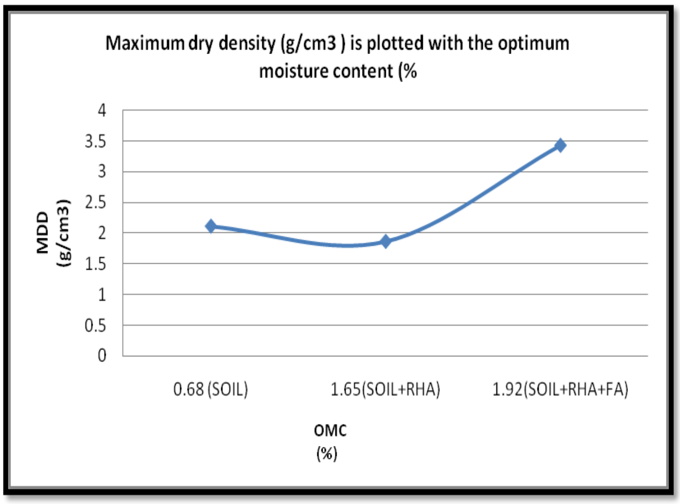


Fig-4 The Maximum dry density (g/cm3) is plotted with the optimum moisture content (%) of only Soil, Soil +RHA and Soil+RHA+FA.

4.3 Direct Shear Test

Mix proportion	Normal stress (Kg/cm 2)	Shear stress at failure (Kg/cm2)	Maximum shear stress (Kg/cm2)	Angle of shear resistance (degree)	Apparent cohesion Kg/cm
Soil only	0.5	0.059	0.409	35	0.059
	1	0.162	0.759		
	1.5	0.254	1.109		
Soil + 10%RHA	0.5	0.073	0.152	9	0.073
Soil + 15%RHA	1	0.079	0.231		
Soil + 20% RHA	1.5	0.086	0.310		
Soil + 10%RHA+5%FA	0.5	0.074	0.171	13	0.074
Soil + 15%RHA +10%FA	1	0.0799	0.268		
Soil + 20%RHA +15%FA	1.5	0.086	0.365		

Table-6 Direct Shear Test Results

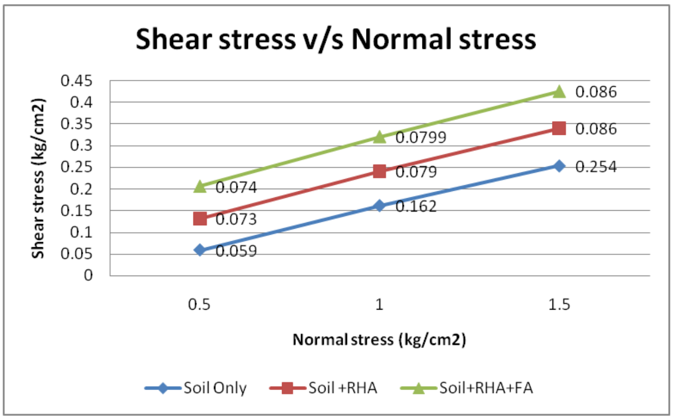


Fig-5 Graph shows Normal stress Vs Shear stress for Soil, Soil+RHA & Soil+RHA+FA

5. SUMMARY AND CONCLUSIONS

It may be concluded that the effect of rice husk ash and fly ash showed a significant variations in its engineering properties. The moisture content of soil decreases with the addition of rice husk ash and if we increase the percentage of rice hush ash, at certain point the moisture content starts increasing. The addition of fly ash to rice husk increases the plastic limit of soil until it reaches a point after which it starts reducing. The addition of fly ash and rice husk ash to the soil increases the plastic limit in case of coarse grain soil as the plasticity index is seen to increase. The change in behavior depends upon the mix proportion and drying. The MDD and OMC of RHA with soil mix has been decreased and increased respectively as the RHA content has been increased.

If 10% of rice husk ash is added to the soil, the moisture content decreases from 10.7% to 8.69%. Later, the addition of 5% of fly ash to soil containing 10% of rice husk ash the moisture content start increases from 8.69% to 10.721.The plastic limit of soil is increased from 17.05% to 13.33% after the addition of 10% of rice husk ash. Later, the addition of 5% of fly ash to the soil containing rice husk ash, the plastic limit start increases from 13.33% to 19.04%.The liquid limit of soil is increased from 66% to 34% with 25 numbers of blows after the addition of rice husk ash. Later the addition of fly ash to the soil containing rice husk ash, the liquid limit starts increases from 34% to 28.226%.The plastic index of soil is much more than the rice husk ash containing soil and fly ash.

The maximum dry density is decreased from 2.115 to 1.861 g/cm3 after the addition of 10% of rice husk ash and optimum moisture content is also increased from 0.671% to 1.655%. Later the addition of 10% of fly ash to the soil containing 15% of rice husk ash, the maximum dry density is increased from 1.861 to 1.926 g/cm3 and the optimum moisture content start increasing from 1.655% to 3.43%. The shear stress at failure is also increased from 0.0594 to 0.0738 kg/cm2 under the normal stress of 0.5 kg/cm2 . Later, the addition of 5% of fly ash to the soil and rice husk ash, the bearing capacity is increased from 59.829 to 65.057 KN/m2 and the shear stress at failure is also increased from 0.0738 to 0.0748 kg/cm2 under the normal stress of 0.5 kg/cm2 . The angle of friction is decreased after the addition of rice husk ash from 35^0 to 9^0 and later on the addition of fly ash to the soil containing RHA, the angle of friction tend to increases from 9^0 to 11^0 . To the contrary we can conclude that addition of admixture to the soil in the form of by products, waste products; cement etc changes the engineering properties of the soil by manifolds which can be brought to desired use as per specific need.

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