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A Comparative Study of using Fly Ash and Rice Husk Ash in Soil Stabilization

Alok Kumar Chaudhary[1], Puspendra Kushwaha[2]

[1]Student, [2]Assistant Professor,
[1,2]RKDF College of Engineering, Bhopal, Madhya Pradesh, India

ABSTRACT

Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. In this study, Stabilization of soil using solid wastes like Rice husk Ash and Fly ash which reduces the cost of chemical stabilization a review is made on Rice husk ash and Fly ash. RHA has rich amount of silica and FA believed to be one of the best pozzolans which may be used as chemical stabilizers for soil stabilization. The rice husk ash and fly ash is mixed in various proportions with soil like 5%, 10%, 15% and 20%. Various tests were also conducted on these mixes in order to find optimum proportions.

KEYWORDS: *Rice husk ash, Fly ash, Soil stabilization, Chemical stabilizer, Index properties, California bearing ratio, Cation Exchange Capacity (CEC)*

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1. INTRODUCTION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.

Soil stabilization in a broad sense includes various methods used for modifying the properties of soil to enhance its engineering performance. By stabilization the major properties of soil, i.e., volume stability, strength, compressibility, permeability, durability and dust control is improved, which makes the soil suitable for use. There are different methods of stabilization, which include physical, chemical and polymer methods of stabilization. Physical methods involve physical processes to improve soil properties. This includes compaction methods and drainage. Drainage is an efficient way to remove excessive water from soil by means of pumps, pipes and canal with an aim to prevent soil from swelling due to saturation with water. Compaction processes lead to increase in water resistance capacity of soil. Drainage is less common due to generally poor connection between method effectiveness and cost. But, compaction is very common method. Although, it makes soil more resistant to water, this resistance will be reducing over time. Chemical soil stabilization uses chemicals and emulsions as compaction aids, water repellents and binders. The most effective chemical soil stabilization is one which results in non-water-soluble and hard soil matrix. Polymer methods of stabilization have a number of significant advantages over physical and chemical methods. These polymers are cheaper and are more effective and significantly less dangerous for the environment as compared to many chemical solutions. In the present study two difficult soils, expansive soil and dispersive soil are considered for effectiveness of geopolymer and biopolymer stabilization. (Afrin, 2017)

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases. (Afrin,2017)

2. LITERATURE REVIEW

In terms of methods of stabilization of soils, there are physical, chemical and biochemical stabilization methods. Various efforts have been made to stabilize expansive soil and dispersive soil for engineering use. Variety of stabilizers may be divided into three groups (a) conventional stabilizers (lime, cement etc.), (b) by-products stabilizers (fly ash, quarry dust, phosphor-gypsum, slag etc.) and (c) non-traditional stabilizers (sulfonated oils, potassium compounds, polymer, enzymes, ammonium chlorides etc.) (Petry 2002).

Prasanna et al. (2022) presented the soil samples that were stabilised by fly ash and rice husk ash wastes, which contribute a major part in increased disposal problems. In the present study fly ash and rice husk ash and the combination of fly ash and rice husk ash was added in varying percentages such as 5%, 10%, 15%, 20% and 25% to improve the soil properties.

Subramaniam et al. (2022) presented and compared the feasibility of using industrial waste fly ash (FA) and agricultural waste rice husk ash (RHA) for sustainable pervious concrete production. An experimental program was performed with substitution of FA and RHA contents of 5%, 10%, 15% and 20% as cement replacement and water to binder ratio of 0.3, 0.35, 0.4 and 0.45.

Raja et al. (2022) presented two waste materials: Rice Husk Ash (RHA) and lime sludge for stabilization because they are locally available nearby, the quantity of trash that must be disposed of and therefore reducing pollution. These two react to generate complexes that fill in the gaps in the structure of the soil, reducing shrink or swell characteristics and plasticity, and therefore enhancing the strength of the soil.

Hosamani et al. (2022) presented the properties such as maximum dry density, optimum moisture content, shear strength and free swelling index of black cotton soils stabilized with admixtures with varying percentage and curing periods. The properties of untreated expansive soil were:1) Unconfined compressive strength=24kPa, 2)Free Swelling Index=52%, 3)Plasticity Index=46% 4) Maximum Dry Density(MDD) and Optimum Moisture Content(OMC)=1.22g/cc & 34%. UCS values of soil when RHA was added was found to be higher i.e. 179kPa whereas for BA was 141kPa at 15% dosage for 14 days curing.

Kishor et al. (2022) presented the behaviour of amended expansive soil with rice husk ash, sugarcane bagasse ash, and liquid alkaline activator stabilizer for highway subgrade. The liquid alkaline activator used is a mixture of sodium metasilicate ($Na_2SiO_3.9H_2O$) and sodium hydroxide (NaOH) solutions of 1 M and 10 M concentration respectively.

Sukkarak et al. (2021) presented the effect of industrial/agricultural waste materials including fly ash (FA) and rice husk ash (RHA) as Portland cement replacement on properties of stabilized lateritic soil as a road construction material.

Vattimalla et al. (2021) presented Ash and Fly ash which reduces the cost of chemical stabilization a review is made on Rice husk ash and Fly ash. RHA has rich amount of silica and FA believed to be one of the best pozzolans which may be used as chemical stabilizers for soil stabilization.

Dávalos et al. (2021) presented Wastes such as coal and rice husk ashes, which are widely available in Colombia, were successfully used to synthesize glass-ceramics in the (Na_2O)–CaO–Al_2O_3–SiO_2 system, which are obtained from thermally treating the parent glasses.

Nnabuihe et al. (2021) presented the effects of lime stabilization on the soils were evaluated using their geotechnical properties including liquid limit, plasticity index, linear shrinkage, Maximum Dry Density (MDD) and California Bearing Ratio (CBR).

Lo, F.C et al. (2021) investigated an effective way to reuse coal fly ash (CFA), coal bottom ash (CBA), and rice husk ash (RHA) as partial replacements of ordinary Portland cement in pervious concrete. In experiments, single and binary replacement by these ash materials was conducted via cement material substitution in pervious concrete.

3. MATERIAL USED AND METHODOLOGY

To compare the effects of Rice Husk Ash and Fly Ash on soil as soil stabilizers they mixed in various proportions with soil. These mixers are further tested to find index properties (specific gravity, liquid limit test, plastic limit test) and Engineering properties (California bearing ratio test).

Soil Preparation And Experiments: Fly ash is mixed in varying percentage of 10,15,20,25 with Natural soil. RHA is mixed in varying percentage of 5,10,15,20 with Natural soil.

4. RESULTS AND DISCUSSION

Plasticity index-

Plasticity index of black cotton soil is decreases at varying percentage of RHA, Fly ash and Lime. Compaction parameters –

There is not major change in Maximum dry density (MDD) and Optimum moisture content (OMC) of Blackcotton soil with stabilizers.

California bearing ratio (CBR) –

The California bearing ratio (CBR) values of BC soil increases with increase of RHA, fly ash and Limecontent.

4.1. ATTERBERG'S LIMITS

The liquid limit of the soil with varying percentage of Fly Ash and Rice Husk Ash are given inTable 1 & 2 and fig 1

Table 1 liquid limit of flyash

% of Fly ash	Liquid limit (%)
0 (BC Soil)	55
5	48
10	49
15	50
20	50

Table 2 liquid limit of rice husk ash

% of Rice husk ash	Liquid limit%
0 (BC Soil)	55
5	49
10	50
15	52
20	-

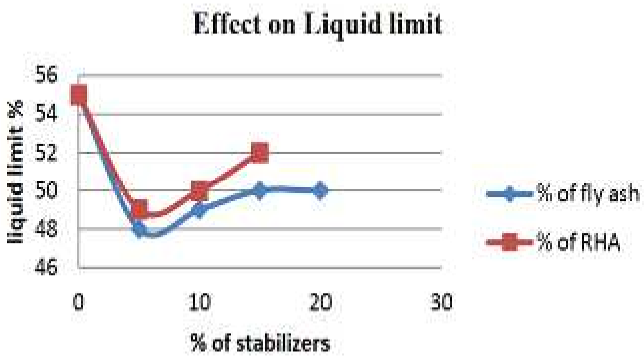

Figure 1 Effect on liquid limit

➢ **Plastic limit of the soil with varying percentage of fly ash and rice husk ash are in Table 3 & 4 and**

Table 2 Plastic limit of flyash

% of Fly ash	Liquid limit (%)
0 (BC Soil)	32
5	29
10	27
15	28
20	32

Table 3 Plastic limit of rice husk ash

% of Rice husk ash	Liquid limit (%)
0 (BC Soil)	32
5	29
10	29
15	31
20	-

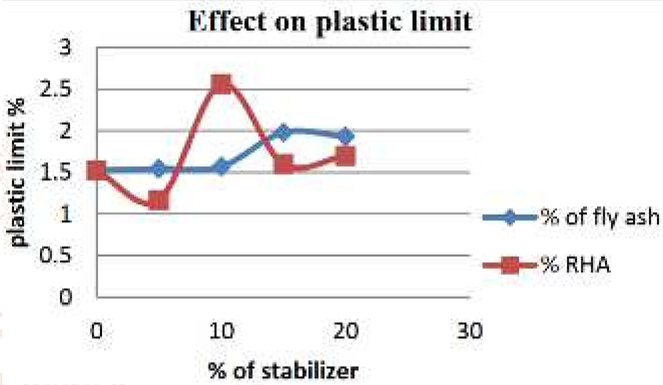

Figure 2 Effect on Plastic limit

4.2. COMPACTION

➢ **Maximum Dry Density of the soil with varying percentage of fly ash and rice husk ash are inTable 5 & 6 and fig 3**

Table 4 Maximum Dry Density of flyash

% of Fly ash	MMD(gm/cm²)
0 (BC Soil)	1.71
5	1.58
10	1.64
15	1.7
20	1.65

Table 5 Maximum Dry Density of rice husk ash

% of Rice husk ash	MMD(gm/cm²)
0 (BC Soil)	1.71
5	1.66
10	1.62
15	1.64
20	1.65

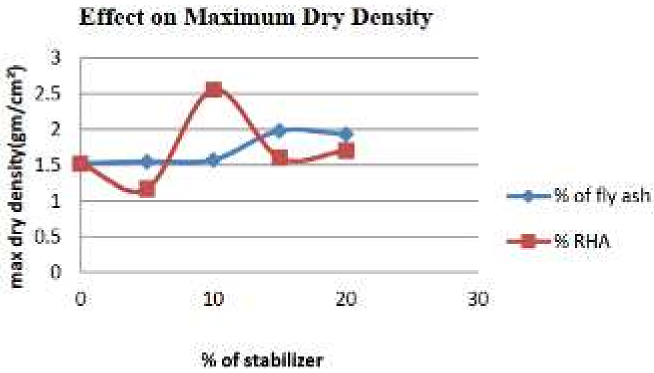

Figure 3 Effect on Maximum dry density

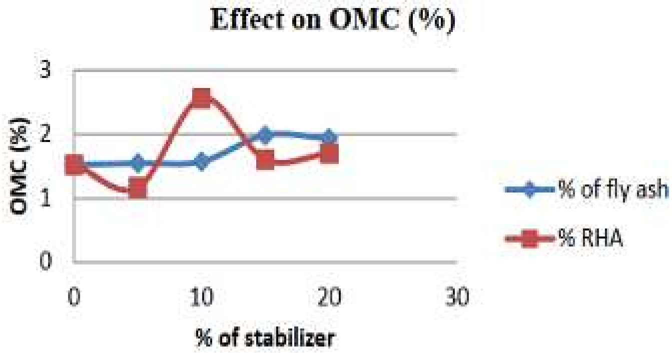

Figure 4 Effect on OMC%

4.3. OPTIMUM MOSITURE CONTENT

- **Optimum moisture content of the soil with varying percentage of fly ash and rice husk ash are inTable 7 & 8 and fig 4**

Table 6 Optimum moisture content of flyash

% of Fly ash	OMC (%)
0 (BC Soil)	18
5	16
10	15
15	15
20	18

Table 7 Optimum moisture content of rice husk ash

% of Rice husk ash	OMC (%)
0 (BC Soil)	18
5	15
10	15
15	18
20	18

4.4. CBR VALUES

Table 8 CBR VALUES of flyash

% of Fly ash	CBR Value
0 (BC Soil)	1.52
5	1.545
10	1.57
15	1.98
20	1.93

Table 9 CBR VALUES of rice husk ash

% of Rice husk ash	CBR Value
0 (BC Soil)	1.52
5	1.17
10	2.56
15	1.60
20	1.70

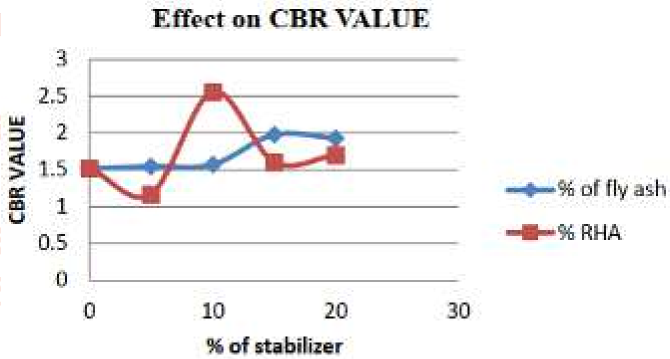

Figure 5 Effect on CBR Value

- **CBR Values of the soil with varying percentage of fly ash and rice husk ash are in Table 9 & 10and fig.5**

Table 10 CBR Values of the soil with varying percentage of fly ash and rice husk ash

S.NO	Soil+ % of (Fly ash/ RHA)	Liquid Limit (%)	Plastic Limit (%)	Maximum Dry Density(gm/cm²)	Optimum Moisture Content (%)	CBR Value
1	BC SOIL	55	32	1.71	18	1.52
2	5% FLY ASH	48	29	1.58	16	1.545
3	10% FLY ASH	49	27	1.64	15	1.57
4	15% FLY ASH	50	28	1.7	15	1.98
5	20% FLY ASH	50	32	1.65	18	1.93
6	5% RHA	49	29	1.66	15	1.17
7	10% RHA	50	29	1.62	15	2.56
8	15% RHA	52	31	1.64	18	1.6
9	20% RHA	-	-	1.65	18	1.7

The main objective of this research work was to study the effect of adding RICE HUSK ASH and FLY ASH individually on the engineering properties of soil sample. Extensive experimental work was carried out on the engineering properties of the test soil. Major changes were observed in some of the engineering properties of the test soil on the addition of RICE HUSK ASH and FLY ASH.

Plasticity index: Plasticity index of black cotton soil is decreases at varying percentage of RHA, Fly ash and Lime.

Compaction parameters –
There is not major change in Maximum dry density (MDD) and Optimum moisture content (OMC) of Black cotton soil with stabilizers.

California bearing ratio (CBR) – The California bearing ratio (CBR) values of BC soil increases with increase of RHA, fly ash and Lime content.

5. CONCLUSION

- Liquid limit and plastic limit of Black Cotton soil increase with increasing % Fly ash and % Rice huskash.
- CBR value of Black Cotton soil also increase with increasing varying % Rice husk ash. The optimumpercentage of Rice husk ash at 20% for gave the best result.
- CBR value of Black Cotton soil also increase with increasing varying % fly ash. The optimum percentage of fly ash at 20% for gave the best result.
- The addition of RICE HUSK ASH alone to the test soil resulted in decrease in the value of MDD.
- The addition of FLY ASH alone to the test soil resulted in increases to 15% then after decreases in thevalue of MDD.
- The addition of RICE HUSK ASH alone to the test soil resulted in OMC increase.
- The addition of FLY ASH alone to the test soil resulted in OMC increase.
- RHA 20% and FA 20% are the optimum proportions for effective results Silica present in RHA and the binding agent in FA is capable to replace the exchangeable ion present in clay mineral thus can reduce shrinkage and swelling property of clay minerals.
- The waste material such as fly Ash and Rice husk ash can be used effectively in the civil engineering construction.

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