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Experimental Study on Strength Characteristics of Fly Ash and Rice Husk Ash added Clay Soil

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Abstract. Clay soil is usually stiff in dry state, but in wet state, it loses its stiffness and becomes softer. Various types of clay minerals have unique characteristics of low bearing capacity and certain compressibility. Especially Montmorillonite clay mineral exhibits more degree of swelling and shrinkage and loss of strength when moisture added. According to recent research, rice husk ash is a potential improving material based on its pozzolanic activity. In this study, to improve the engineering properties of expansive clay the admixture such as fly ash and rice husk ash will be added in different percentages as 5, 10, 15 and 20. For the laboratory test that includes atterberg's limits test, standard proctor compaction test and unconfined compression test were conducted on locally collected expansive soil with various percentages of these two stabilizers in order to examine their influences. The maximum values of Unconfined Compressive Strength were obtained corresponding to 15% Rice Husk Ash and 20% Fly ash.

Introduction

Building foundations bears the entire super structure load. The soils beneath the foundations hold play a crucial part in holding the foundation. But Expansive soils, such as montmorillonite deforms more provides lesser resistance against the foundation load. One-fifth of the Indian land is covered by these expansive soils, produces difficulty to building & Road construction activities.

A combination of swelling and shrinkage occurs under moisture variations, causing structural failures. They are not recommended due to low strength, high compressibility and volumetric changes. Improvement of soils may be done through modification of soils or stabilization technique. When cement, fly ash, etc. is added to a soil, it changes its properties called soil modification.

Soil stabilization

Soil stabilization alters the soil properties by physical or chemical means to improve the engineering quality of the soil. We shall increase the bearing capacity of the soil, reduces the compressibility & permeability. The structure long-term performance will be boosted. We shall ensure the good stability of the superstructure particularly in case expansive soil, the chemical stabilization of clay soil using lime is becomes common method and requires more investment, when used for road constructions.

Materials used

Black cotton soil

Black cotton soil, which is rich in montmorillonite clayey mineral and exhibits higher degree of shrinkage, swelling and compressibility nature under loading due to its chemical composition. Higher the montmorillonite presence, it becomes black or blackish grey in colour. Montmorillonite has the structural composition of 1 octahedral alumina sheet and 2 tetrahedral silica sheets in the structural term defined as 2:1 composition. Due to the Isomorphous substitution they are highly adsorbs the water and forms a diffusible double layer around the surface. It becomes more expansive in nature with increase in moisture content. This water imbibing phenomena is occurring in higher degree comparatively with kaolinite and bentonite clay mineral. Soil with higher montmorillonite mineral quickly deforms when moisture added and results in poor stability.

The sample used for laboratory investigation was collected at a depth of 2 meter from ground surface of the site located in Vadavalli and Veerakeralam of Coimbatore district. Location: 11.006729755508342 N, 76.91312369798602 E

Rice husk ash

Figure.1 shows the rice husk ash collected for our study. From the rice mill industry we shall collect the rice husk, which comes out of the industry as a waste product, after separating the rice millets. In statistical point of view, yearly hundred tonnes of rice husk is produced worldwide. The burn product of rice husk taken ash for this study. The ash holds more than 60% of silica, 49 % of alumina with pozzolanic property. Pozzolanic property of this material aids to use this as a partial complementary constituent of cement. Replacing the cement by considerable amount shall result in economic construction with added advantage of strength improvement of soil sub layer.

We have collected rice husk from Coimbatore for conducting the laboratory investigation on the black cotton soil.

Fig.1. Rice husk ash

Fly ash

Fly ash is a soft and powder like materials results from the coal burning at the power stations. Figure.2 shows that collected locally available Flyash poured on the sample prior to mix. Fly ash also exhibits pozzolanic nature. When it reacts with lime, it becomes cementitious materials. Nowadays flyash are directly used for brick production as well, since it is cheap and exhibiting engineering property.

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Fig.2.Fly ash

Literature review

Harichane et al. (2011) compared the utilization of natural pozzolana, lime and combination of both, with 2 types of cohesive soils. Consistency, undrained triaxial test, UCC strength test and compaction test was carried out on samples mixed with additives and cured for 1,7,28 and 90 days. The combined action of lime and pozzolana improved the properties of soils.

Phanikumar (2009) compared the effect of lime and flyash in counteracting the problems associated with expansive soil. Base Exchange took place while adding lime and fly ash to clay. This reduces the Plasticity Index values, reduction in degree of swell, increase of dry density, decrease of OMC. Consolidation characteristics such as compression index Cc and coefficient of consolidation, Cv increased and then decreased with increase of % addition. The optimum dosage could be fixed as 5% for rice husk ask and 20% for flyash.

Canakcia et al. (2015). A study on stabilization of highly expansive soil prepared by mixing red clay (70%) and bentonite (30%) was carried out. The additives used were lignin, rice husk ash and rice husk powder. The percentages of 5, 10, 15 and 20 of lignin and rice husk powder were used. Rice husk ash in increasing order of 2.5%, 5%, 7.5% and 10% was also used. A moisture content of 25% was adopted for all mixtures. Unconfined Compression strength tests, Swelling test, Atterberg limit test were conducted on the samples cured for 3 and 7 days. The additives improved the strength significantly. Liquid limit decreased and plastic limit increased with increase in percentage of additives. Swelling also reduced upon addition of additives.

Kolay et al. (2011) described the results of laboratory investigation of peat soil stabilized using quick lime (QL), Ordinary Portland cement (OPC) and Class F flyash. UCS of stabilized peat soil increased with increasing percentage of OPC whereas it decreased beyond 6% of QL and 15% of FA. Curing also increases the UCS value.

Methodology

Earlier research works concludes that 20% fly ash will be optimum for stabilizing the clay soil. In our study, we kept fly ash additive as 20% as constant and we increased the rice hush ash in different quantities i.e (5%,10%,15% and 20%)

Laboratory Investigation

Preliminary tests are conducted for representative clay soil in order to determine the Index and Engineering properties. The laboratory investigation includes Atterbergs limits, particle size distribution, Standard Proctor Compaction test, UCS test as per IS Codes

Properties of Representative Clay

S.No.	Property	Clay	Fly ash	Rice husk ash
1	Liquid Limit	40%	-	-
2	Plastic Limit	29.4%	-	-
3	Plasticity Index	12.6%	-	-
4	Shrinkage Limit	10.8%	-	-
5	Specific gravity	2.76	2.02	0.86
6	Maximum dry density	1.642 g/cc		
7	Optimum Moisture content	25%		
8	Unconfined compressive strength	103.9 kN/m^2		

Influence of Fly ash & Rice husk ash in Properties of Soil

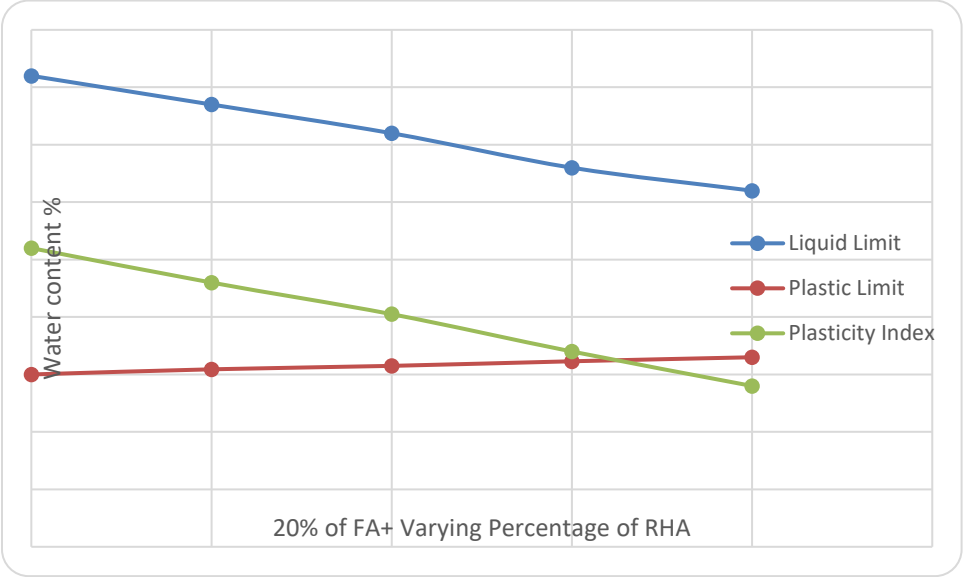

Fig. 3 Influence of Fly ash and Rice husk ash on LL,PL and PI

Figure 3 shows the variation of fly ash and rice husk ash composition influenced the atterberg's limits and plasticity index significantly. For example, Liquid Limit decreased from 82 to 62% with

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the content of 20% fly ash and rice husk ash from 5% to 20%. Plastic Limit increased slightly from 30 to 33%. The Plasticity Index decreased from 52 to 28%, indicating negligible plasticity.

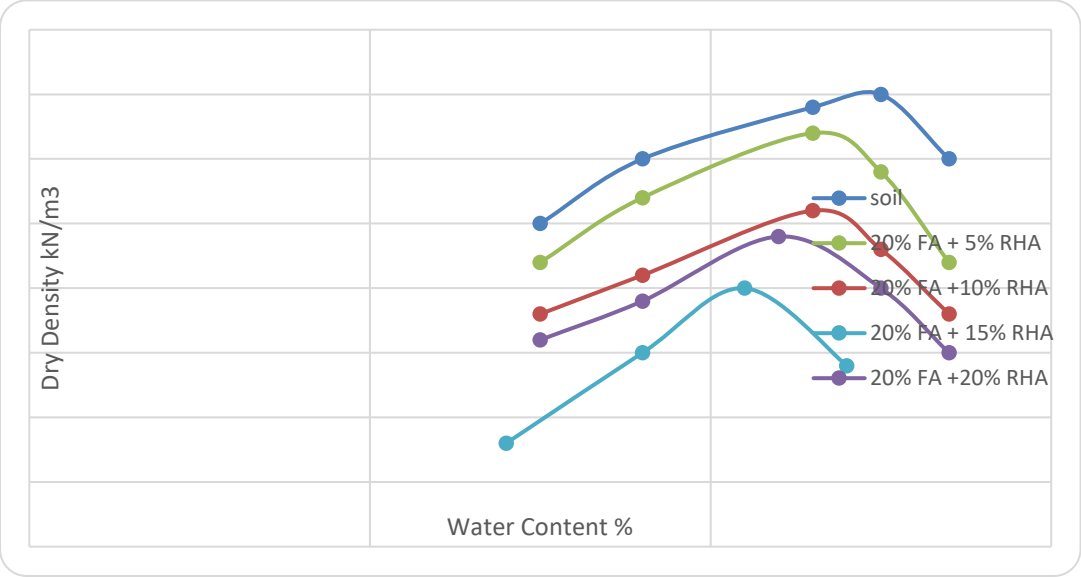

Fig. 4 Influence of Fly ash and Rice husk ash on Compaction characteristics

Figure 4 shows the Comparative results of Proctor compaction for the representative soil and the soil mixed with 20% Fly ash and different rice hush ash contents (5%,10%,15% and 20%). From the graph we observe that the Proctor compaction curves shifting downwards, which clears the increase in additives reduces optimum moisture content and dry density.

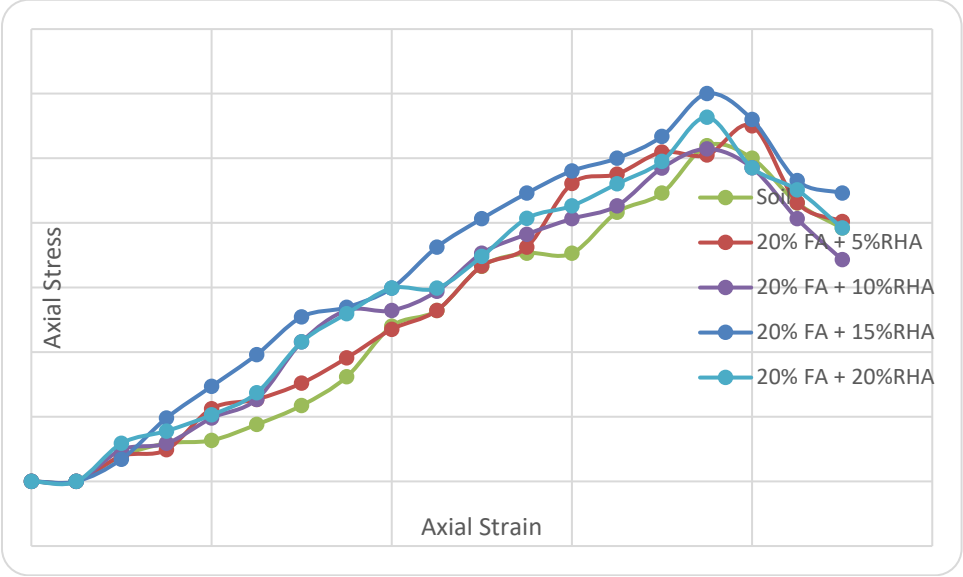

Fig. 5 Influence of Fly ash and Rice husk ash on compressive strength

From the Figure 5, we shall observe that with the increase in % addition of fly ash and rice husk ash content, Compression strength value keep on increasing upto 20 % of fly ash and 15% of rice husk ash after that peak point further addition, decreases the unconfined compressive strength. As a result, combining effect of fly ash and rice husk ash into clay soil improves the soil's strength.

Results & Discussion

It has been found through various laboratory experiments that by keeping the constant fly ash constant and changing the addition percentage of Rice Husk Ash at 5%, 10%, 15%, and 20%, expected engineering properties of soil improved.

The following conclusions were drawn:

1. With increasing percentages of Fly ash and Rice husk ash in black cotton soil, Atterberg's limits are decreases.
2. The shrinkage values were low. Having a low shrinkage rate indicates a lower risk of defect, such as warping and cracking.
3. The maximum dry density value of the soil decreases from 15.5 kN/m^3 to 14kN/m^3 with increase in Rice Husk Ash content and the maximum dry density was obtained in 20% of fly ash and 15% of rice husk ash.
4. The maximum Unconfined Compressive Strength values were obtained corresponding to 15% Rice Husk Ash and 20% Fly ash.

Based on the above said results, Soil properties were improved by using 20% of fly ash and 15% rice husk ash. Hence the optimum value of rice husk ash and fly ash which can be adopted to obtain improved soil properties is the proportion of 20% fly ash and 15% rice husk ash.

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