Effect of Arecanut Husk Ash and Water Hyacinth Stem Ash on Plasticity Behavior of Lateritic Soil

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Abstract:*This paper presents investigations on the influence of arecanut husk ash and water hyacinth stem ash as an additive on the plasticity behavior of soil. Ashes are mixed with the soil at 5, 10, 15 and 20 wt%. It is observed that the arecanut husk ash has decreased the plasticity index, whereas water hyacinth stem ash has increased the plasticity index with the increase in ash content. For finding minimum plasticity value, 15% addition of ANA can be considered as the optimum level.*
Keywords:*lateritic soil; liquid limit; areca nut husk ash; water hyacinth stem ash*
Nomenclature: ANA:arecanut husk ash; WHA: water hyacinth stem ash; ISSCS: Indian standard soil classification system

1. Introduction

Lateritic soil was first recognized by Francis Buchanan, a Scottish physician in southern India in 1807. He named it laterite from the Latin word "letritis" that means bricks and defined as "soft enough to be readily cut into blocks by an iron instrument, but which upon exposure to air quickly becomes as hard as brick, and is reasonably resistant to the action of air and water"[1-2]. Lateritic soil is widely used as fill material for various engineering construction works. The engineering problems identified with lateritic soil are variations in plasticity, grain size distribution, high natural moisture content and high permeability which ultimately affect its strength behavior. The strength behavior of the laterite is very much dependent on the moisture content. Lesser the moisture content, higher is the cohesion and internal friction angle [3-4].

In order to modify or improve some of the properties of the laterite, different products or additional constituents are mixed with it. Many researchers have carried out the stabilization of soil with lime, rice husk ash, fly ash, corncob ash, sugarcane straw *ash* because of their pozzolanic properties [5-9]. These are very effective in ameliorating plasticity of the treated soils by reducing the plasticity index and the swell potential. Disposal of agricultural and bio-waste today is a great problem and accentuated for the quality of our environment. In India per year 6 metric tonnes/hectares of arecanut husk is obtained from an arecanut garden [10]. Similarly water hyacinth has stretched over 2 lac hectares of water surface in the country [11]. This unutilized waste creates an ecological hazard.

The main objective of this paper is provide an experimental insight of effects of the blends of arecanut husk ash and water hyacinth stem ash on plasticity behavior of lateritic soil which is relevant for evaluating the performance of sub-grade soils.

2. Materials and methods

The lateritic soil used in this study was collected from Ganesh Nagar, Guwahati city, Assam. The liquid limit, plastic limit and plasticity index are found to be 52.17%, 24.5 % and 27.67% as per IS: 2720 (Part-5) [12].

Figure 1: Lateritic soil

The specific gravity of the soil is 2.6 and swelling index is negligible. The soil is identified as CH group as per ISSCS. The grain size distribution curve of the soil sample as per IS: 2720 (Part 4)-1985 [13] obtained with dry sieving is shown in Figure 2. In this study oven dried soil specimen is used for all the tests. Many researchers have found that the variation in grain size in the lateritic soil resulting from drying is irreversible and results with more granular characteristics [2].

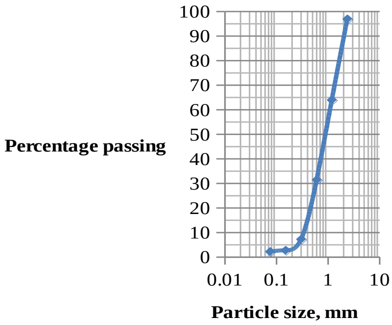


Figure 2: Particle size distribution of untreated soil

Arecanut husk and water hyacinth stem were obtained from local areca nut gardens and ponds of Kokrajhar district, Assam. They were cleaned thoroughly with water and then dried in open sun. After drying they were burnt in electric muffle furnace at 700^0C for 6 hours. The ashes, sieved through 150µ sieve were kept in airtight polythene bags until used. The chemical properties of both the ashes are shown in TABLE 1.

TABLE 1: Oxide composition of the ash samples

Chemical composition	Arecanut husk ash	Water hyacinth stem ash
Silica	28.44%	4.4%
Iron oxide	1.91%	1.27%
Alumina	3.64%	2.2%
Calcium oxide	2.71%	22.61%
Magnesia	3.87%	14%
Sodium oxide	0.24%	0.35%
Potassium oxide	26.52%	14.82%

3. Results and discussions

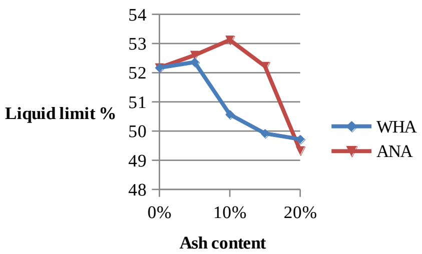
3.1 Variation of Liquid Limit

From Figure 3 it can be observed that 5% to 15% addition of ANA has increased the liquid limit and 20% addition has decreased the limit to 5.45% that of untreated soil. This is possibly because ANA has silica and potassium oxide content of 28.44% and 26.52%, which enhances the high water holding capacity of soil [14]. Potassium oxide reacts with water to produce potassium hydroxide and potassium hydroxide is deliquescent, that have a strong affinity for moisture.

TABLE 2: Blended ratios

Specimen	Blending ratio (by weight %)
LS	100% Soil + 0% Ash
A5	95% Soil + 5% Arecanut husk ash
A10	90% Soil + 10% Arecanut husk ash
A15	85% Soil + 15% Arecanut husk ash
A20	80% Soil + 20% Arecanut husk ash
W5	95% Soil + 5% Water hyacinth stem
W10	90% Soil + 10% Water hyacinth
W15	85% Soil + 15% Water hyacinth
W20	80% Soil + 20% Water hyacinth

On the other hand after addition of 5% WHA a decline in liquid limit value was observed. The possible explanation for the reduction of the liquid limit in both the cases may be due to avalanche of shear strength to zero resulting from agglomeration and flocculation of the clay particles [15].



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• **Figure 3**: Variation of liquid limit with ANA and WHA content

3.2 Variation of Plastic Limit

- The plastic limit of the soil decreases from 24.5% to 18.15% with the increase of WHA content. For ANA, slight reduction in the plastic limit is observed up to 10% addition, beyond which the increase in ANA has marginal effect on plastic limit.The variation of plastic limit with ash content is due to the variation of liquid limit with ash content.

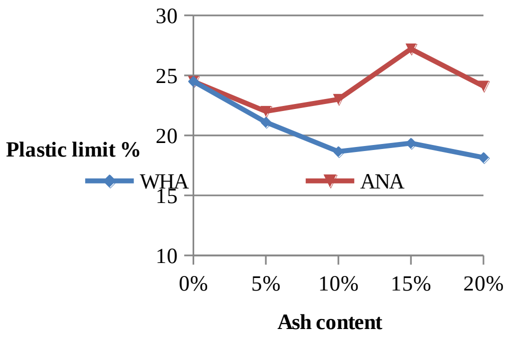
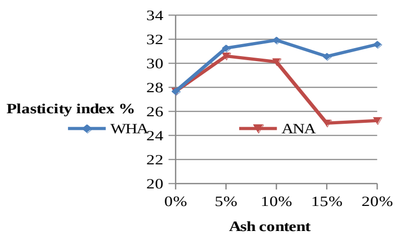


Figure 4: Variation of plastic limit with ANA and WHA content

- **3.3 Variation of Plasticity Index**



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- **Figure 5**: Variation of plasticity index with ANA and WHA content

From the plasticity chart (Figure 6-7), it is observed that soil has shown an immediate increase in plasticity index upon addition of ANA and WHA. Increase in WHA beyond 10% has minor effect on plasticity behavior, while addition of ANA beyond 10% has decreased the plasticity index to 25.23%.

ANA treated soil has come closer to the A-line indicating that the soil with 20% ANA has transformed itself from CH to CI group, while the same pattern is also observed in case of WHA treated soil with 15% and 20% addition.

4. Conclusions

Based on the results of the study conducted, the following conclusions can be drawn:

• Every addition of WHA (5% every time) has continuously decreased the liquid limit and plastic limit.

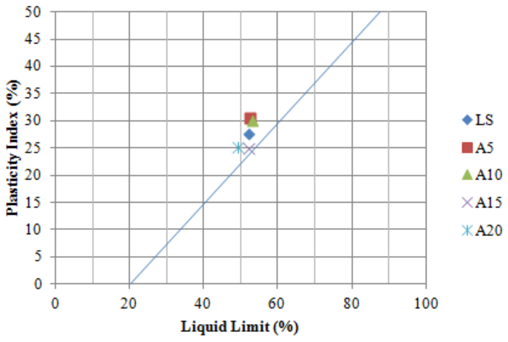

Figure 6: Effect of ANA on plasticity of soil

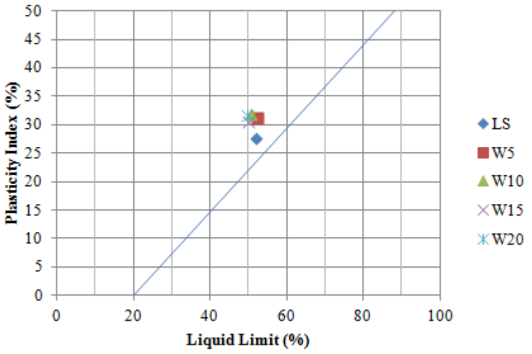

Figure 7: Effect of WHA on plasticity of soil

- Addition of ANA up to 15% has resulted in an increased liquid limit and further addition of ANA results in a sharp decrease in liquid limit.
- 15%-20% WHA and 20% ANA have transformed the soil from CH to CI group (high plasticity to intermediate plasticity).
- Higher quantity of ANA (beyond 10%) has reduced the plasticity index of the soil and this reduction is the indicator of soil improvement. Further increase of ANA (beyond 15%) shows increasing tendency. For a better understanding of this behavior, morphology and particle chemistry analysis of the treated soil by XRD and SEM analysis may be needed.

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Authors Profile

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