Stabilization of Clay Soil Mixed with Wood Ash

Berjees Anisa Ikra, Tamanna Kabir, Anika Nowshin Mowrin, Ahsan Habib

Abstract— Soil stabilization is a process to enhance the physical properties of soils. Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Stabilization of soil can be done by different methods such as mixing the soil with cement, wood ash, brick dust, rice husk etc. In this study wood ash was used with soil for stabilization purpose. For laboratory experiment, standard proctor test was used. In the laboratory experiment, 8%, 10%, 12%, 14%, 16%, 18% water was added in the soil. From the observed data it was found that, within a certain limit the increase of water content increased the value of dry density, after attaining a peak point the dry density decreased with the further increase of water content. From the peak value of the graph, maximum dry density and optimum moisture content can be determined. The same experiment was continued for different percentage (2%, 4%, 6%, 8%, 10%, and 12%) of wood ash mixing with soil. From the experimental value it was observed that maximum dry density of the sample was decreased with the increasing percentage of wood ash with sample.

Index Terms— compaction, dry density, optimum moisture content, soil, stabilization, wood ash.

1 Introduction

FOUNDATION on loose, poor compacted soil has been a problem for engineers for decades. The swell-shrink behavior of soil increases the settlement problem. Due to low shear strength, and low bearing capacity it is becoming more challenging to make construction over these types of soils. These materials exhibit marked changes in physical properties with changes in water content, a hard, dry clay, for example, may be suitable as a foundation for heavy loads so long as it remains dry, but it may become unstable when wet whereas many of the fine soils shrink on drying and expand on wetting, which may adversely affect structures founded upon them or constructed of them. Even when the water content does not change, the properties of fine soils may vary significantly between their natural condition in the ground and their state after being disturbed. The clay often is weak and has no enough stability in heavy loading. Besides, the available lands for construction are also limited. To improve the soil conditions, different methods are used i.e. stabilization, removal of soil, replacement of soil, grouting, vibroflotation, vibro-rod, stone column, using geotextile reinforcement [3], [4], [8], [9], [10], [11]. Both chemical and physical properties of soil can be improved by these methods. Compaction and consolidation are very effective for sandy soil but it takes longer time for clayey soil. These methods are not suitable for improving the properties of organic soils [2]. Stabilization is the fundamental process of changing the chemical properties of soft soils by adding stabilizers or binders, either in wet or dry conditions to increase the strength and stiffness of the originally weak soils.

Soil sabilization can be utilized on roadways, parking areas, site development projects, airports and many other conditions where sub-soils are not suitable for construction. Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. This process can be done using various of additives, including lime, fly-ash, and Portland cement. Other material byproducts used in stabilization include lime-kiln dust (LKD) and cement-kiln dust (CKD).

Chemical stabilization of soil is an effective and economic solution for soil improvement where the stabilizers are cement, wood ash, fly ash etc. The selection of chemical stabilizers depends on several factors such as dry density, shear strength, workability, availability, durability.

The objective is to make soil capable of carrying load by improving the characteristics at site. In order to ensure the increase of bearing capacity of the soil and the decrease of the settlement of the structures, the shear strength has to be increased and the compressibility of the soil has to be decreased. Sometimes, the aim is to decrease the permeability and dry density of the soil. Scientists, engineers and technologists are looking for materials which can be used as replacement for conventional materials or which possess such properties which would enable their use for new designs and innovation. For this purpose, a large amount of laboratory experimental studies has been implied, wherein soil is mixed with artificial and natural fibers. Soils have been mixed with fibers like hair, bamboo Coconut (coir), fiber Sisal, palm fiber, jute, flax, and pine etc. Lime, cement, calcium chloride, sodium chloride etc can also be added with soil to acquire stabilization.

Wood is an extensively used fuel which increases the combustion residue. Wood ash from forest industries and district heating plants is a very heterogeneous product. Differences in biomass fuels, combustion techniques and treatment of the ashes cause the wood ash to vary widely in solubility, nutrient

- *Berjees Anisa Ikra is currently working as a lecturer in Department of Civil Engineering at Stamford University Bangladesh, PH-+8801790233880. E-mail: anisaikra@gmail.com*
- *Tamanna Kabir is currently working as a senior lecturer in Department of Civil Engineering at Stamford University Bangladesh, PH-+8801675197699. E-mail: engr.tamannakabir@gmail.com*
- *Anika Nowshin Mowrin is currently working as a senior lecturer in Department of Civil Engineering at Stamford University Bangladesh, PH-+8801674526989 E-mail: mowrinanika@gmail.com*
- *Ahsan Habib is currently working as a senior lecturer in Department of Civil Engineering at Stamford University Bangladesh, PH-+8801733978789 E-mail: ahsan090063@gmail.com*

concentrations, trace metal contents and in the other compounds present. Wood ash is a gray material produced from the wood combustion. As an alternative solution, this ash can be used as a potential soil stabilizer. The chemical composition of wood ash suggests that it can be used as substitute of CaO; also, the concentration of heavy metals present in the wood ash is very low [5], [6].

The dry density of wood ash-soil mixture is an important parameter as it controls the strength, compressibility, and permeability. Densification of ash improves the engineering properties [7]. The method of energy application, amount of energy applied, grain size distribution, plasticity characteristics, and moisture content at compaction are important factors that affect the dry density.

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2 METHODOLOGY

The purpose of the study is to determine the dry density and optimum moisture content of clayey soil mixing with different percentage of wood ash. Soil sample was collected for laboratory experiment the site at road no.12, House no.05, Khilgaon, Dhaka, Bangladesh. It was more then 8-10 feet deep soil. Fig. 1 shows the soil sample used for this study.

Fig. 1. Soil sample used for the study.

To study the influence of the wood ash on the mechanical properties of the treated samples, it is crucial to maintaining consistency between the sample preparations. It was significant that consistency among the samples could be achieved by controlling the mixing water. In this investigation, samples were prepared using their corresponding optimum moisture content (OMC) in order to maintain the consistency. Standard proctor compaction tests were performed on the wood ash-soil mixtures at different wood ash-soil ratios following ASTM D 698. A premeasured amount of wood ash, measured as percent of dry soil by weight, was mixed thoroughly to produce a homogeneous wood ash-soil mixture. Water was added slowly during mixing. In the Standard Proctor Test, the soil is compacted by a 5.5 lb. hammer falling a distance of one foot into a soil filled mold. The mold is filled with three equal layers of soil, and each layer is subjected to 25 drops of the hammer. The other materials used for laboratory testing are molds, manual rammer, extruder, balance, drying oven, mixing pan, towel, #4 sieve, moisture cans, graduated cylinder, straight edge etc.

Before conducting the compaction test, the nontreated and ash-treated soils (2%, 4%, 6%, 8%, 10% and 12% ash content) were mixed with water for about ten minutes by hand. After that, the mixtures were put into polyethylene bags and mixing was continued by shaking, overturning, and pressing the bag to squeeze out the air from the soil voids. A series of standard proctor tests on nontreated and ash-treated soils were conducted according to ASTM D 698. The specification of standard proctor test method used in this study is given in Table 1.

Table 1
Specification of standard proctor test.

	Method A	Method B
Material	≤ 20% Retained on No.4 Sieve	>20% Retained on No.4 ≤ 20% Retained on 3/8" Sieve
For test sample, use soil passing	Sieve No.4	3/8" Sieve
Mold	4" DIA	4" DIA
No. of Layer	3	3
No of Blows/ layer	25	25

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3 RESULT AND DISCUSSION

Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8 shows the effect of wood ash on the optimum moisture content and maximum dry density for 0%, 2%, 4%, 6%, 8%, 10% and 12% wood ash respectively.

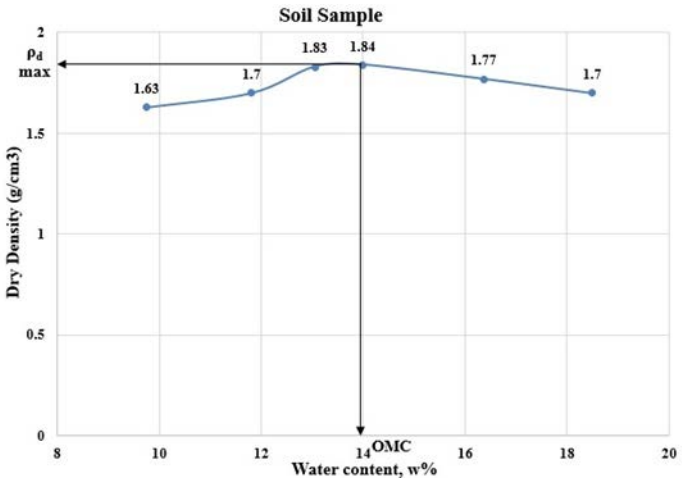

Fig. 2. Water content vs. Dry density curve for no ash wood mixture.

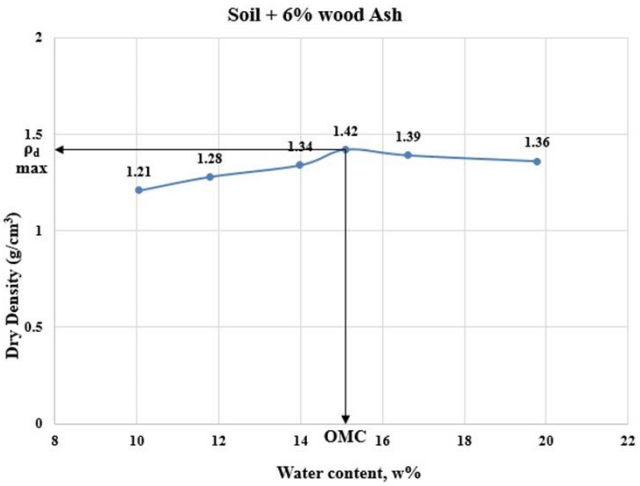

Fig. 5. Water content vs. Dry density curve for 6% ash wood mixture.

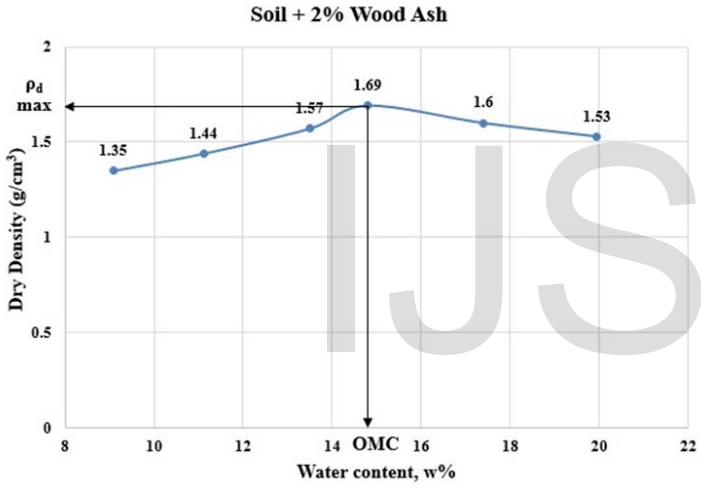

Fig. 3. Water content vs. Dry density curve for 2% ash wood mixture.

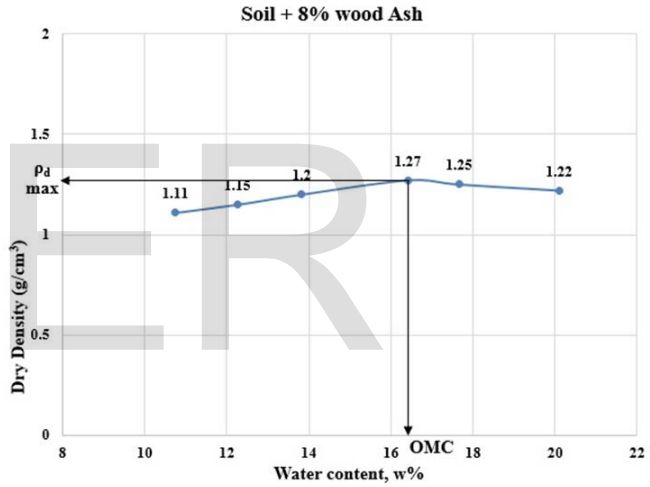

Fig. 6. Water content vs. Dry density curve for 8% ash wood

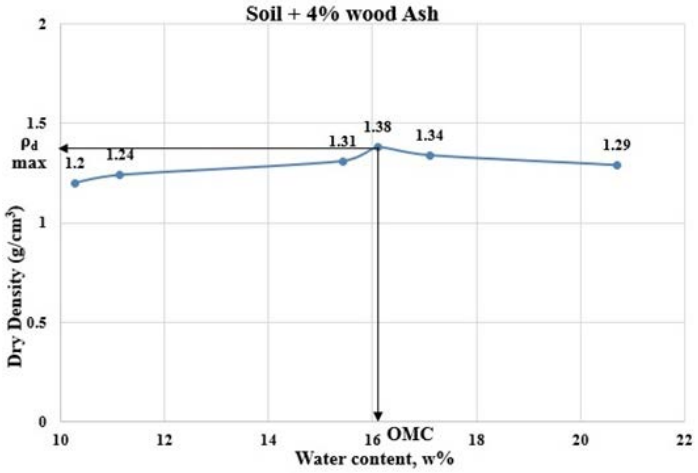

Fig. 4. Water content vs. Dry density curve for 4% ash wood mixture

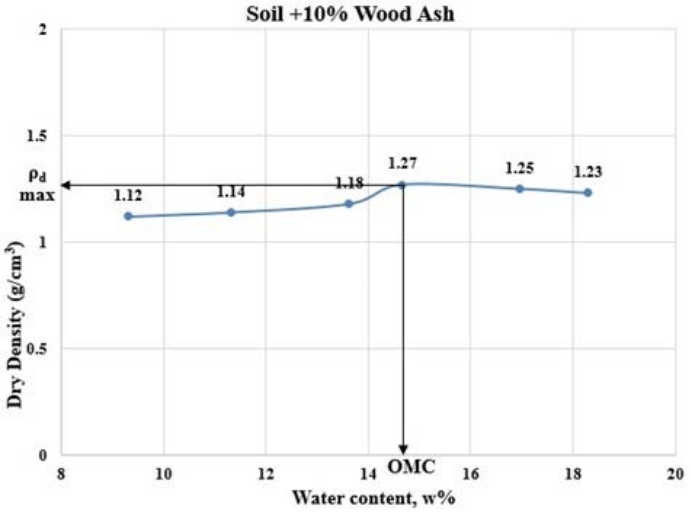

Fig. 7. Water content vs. Dry density curve for 10% ash wood mixture.

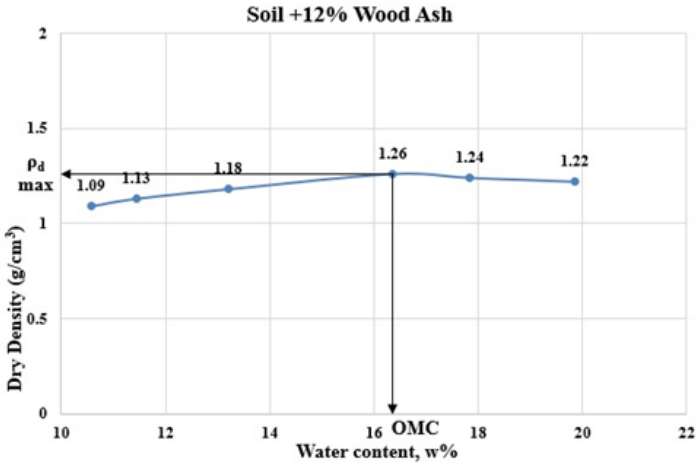

Fig. 8. Water content vs. Dry density curve for 12% ash wood mixture.

Table 2 summarizes the optimum moisture content and maximum dry density for different percentage of wood ash.

Table 2
Effect of Wood ash on Maximum Dry Density and Optimum Moisture Content (OMC).

% Wood Ash.	Maximum Dry Density. (g/cm3)	Optimum Moisture Content. %
0	1.84	13.99
2	1.69	14.80
4	1.38	16.10
6	1.42	15.10
8	1.27	16.41
10	1.27	14.67
12	1.26	16.36

It can be seen that with the increasing percentage of wood ash, optimum water content increases from 13.99% to 16.36%, while the dry density decreases from 1.84 cm/gm^3 to 1.26 cm/gm^3. This trend is similar to Okagbue [1]. The 2%, 4%, 6% 8% and 10% wood ash mixture shows the decrease in dry density with the increase in optimum moisture content. The decreased in dry density is initiated by the flocculation of clay through cation exchange reaction. On the other hand, the optimum moisture content of soil increases with the wood ash increase because more water is needed for forming Ca (OH) and dissolution of this product into Ca and OH ions. Besides that, the more the fines, the more the surface area, so more water is required to provide good lubrication. The ash content also decreases the quantity of free silt and clay fraction, forming coarser materials, which occupy larger spaces for retaining water.

4 Conclusion

In this study, it can be seen that wood ash is capable of improving one of the major geotechnical properties i.e. compaction. Wood ash-soil mixtures show relatively well-defined moisture-density relationships, varying with mixture ratios. The soil was stabilized through 2%, 4%, 6%, 8% and 10% wood ash content. As wood ash content increases, optimum water content increases and the dry density decreases. The dry unit weight for fly ash-soil mixtures is lower than those of typical compacted soils. Wood ash reduces the maximum dry density of the soil, while more water content is necessary for flocculation of soil particles through cation exchange reaction. So, it can be said that the wood ash mixture can be a good soil stabilizer as it has the advantage of lessen dry density of soil.

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