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Study on the Geotechnical Properties of Biochar Stabilized Soil

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Abstract:

Biochar is a carbon rich compound produced through pyrolysis of organic matter. This study investigates the effects of locally produced biochar amendment on mechanical properties of clay. Biochar can be used as an eco-friendly construction material for problematic soil improvement.The goal is to alter the mechanical properties of the soil through the methods known as soil improvement technique. Biochar is added in varying percentages like 2, 5, 8, 10 and 12% to the soil samples. From compaction test, maximum dry density (MDD) and optimum moisture content (OMC) are to be determined for bentonite soil. Strength parameters for clayey soil are obtained from unconfined compressive strength. Increasing the biochar to soil ratios led to a reduction in the plasticity index due to increase in plastic limit and decrease in liquid limit.

Keywords **—Stabilization, Biochar, Compaction, CBR, Unconfined compressive strength.**

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I. INTRODUCTION

Soil stabilization is widely used in connection with road, pavement and foundation construction. It improves the engineering properties of soil such as strength, volume, stability, durability, to reduce the pavement thickness as well as cost. Soil is a construction material which is available in abundance. Earth has been used for the construction of monuments, tombs, dwellings, etc.

The study of engineering behaviour of different types of soils is extremely important because all civil engineering structures will have to be rested and founded on soil. The purpose of soil stabilization is to increase bearing capacity and reduce settlement and deformation.

The presence of problematic soils often requires the use of soil improvement technologies to enhance the exiting ground or fill materials. Biochar is a carbon rich material that is produced by thermochemical conversion of biomass). This biomass can be produced from a variety of sources including: agricultural waste, logging residues, wood production waste, urban wood-waste, and other biological sources (Garcia-Perez et al. 2010). The produced biochar has been used in agricultural and environmental remediation projects as a type of carbon capture technology for quite some time (Hansen et al. 2015, Xie et al. 2015a, 2015b). However, civil engineering application outside of environmental remediation had not been well explored. Recently, several authors have looked into the effects of biochar on mechanical properties of soil (Lu et al. 2014, Reddy et al. 2015, Yargicoglu and Reddy 2017) as well as possible applications as a construction material (Gupta and Kua 2017). However, it should be noted that the type of feedstock and production process used have significant impacts on the properties and quality of biochar (International Biochar Initiative 2015). In addition, previous studies indicated that the soil properties and microbial and atmospheric conditions will also affect the benefit of amending soils with biochar (Latifi et al. 2015; Latifi et al. 2016).

MATERIALS AND METHODOLOGY

A. Soil

The soil in this study is collected from kochi..The properties of the soil are studied using standard procedures and the results are tabulated in table.

TABLE 1
Properties of Bentonite clay

Soil properties	Specifications
Specific gravity	2.59
Liquid limit (%)	336

Plastic limit (%)	46.79
Shrinkage limit (%)	12.4
IS classification	CH
UCS (kPa)	112.7
OMC (%)	38
Dry density (g/cc)	12.65

B. *Biochar*

The stabilizing agent used in the investigation is biochar. For studying the effect of biochar in soils, different tests were conducted and were added in different concentrations i.e., various percentages. The properties of the biochar are given in the table below:

TABLE 2.
Properties of biochar

PROPERTIES	SPECIFICATIONS
Optimum moisture content (%)	0.94
Total moisture content (%)	4.08
Particle size (mm)	4.75 passing
Total ash (%)	1.77
Fixed carbon(%)	66.37
Volatile matter (%)	30.92
Colour	Black

Fig 1Biochar

III.TEST PROCEDURE

In this study the soil is stabilized using biochar. The soil was treated with different percentages of nano silica like 2, 5, 8 10 and 12%. The atterberg limit, compaction characteristics and unconfined compressive strength are determined as per IS.

IV. RESULT AND DISCUSSIONS.

A. *Compaction characteristics.*

IS light compaction test was conducted on various percentages of biochar (2%, 5%, 8%, 10% and 12%) with bentonite soil in accordance with the procedure laid in IS: 2720 PART 7 to study the moisture content and dry density relationship. From the test result it is observed that increase in large amount of biochar percentage in soil-biochar mix, OMC got increased and MDD got decreased. The variation in the compaction characteristics are represented in Fig 1 and Fig 2. The data from the test indicates that the optimum moisture content of stabilized soil are increases than that of raw soil due to absorption of water bybiochar. The maximum dry density was noted to decrease slightly with increase in addition of biochar due to difference in specific gravity of materials.

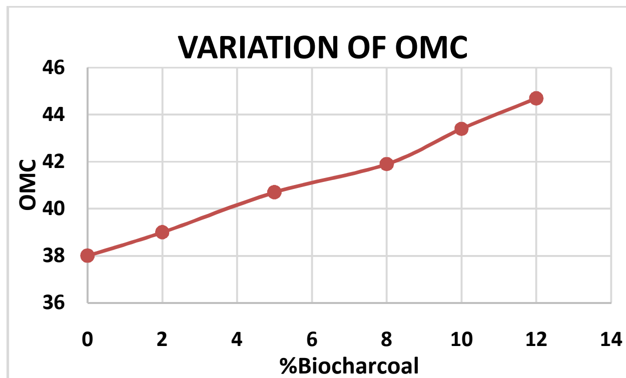

Fig 2Variation on OMC.

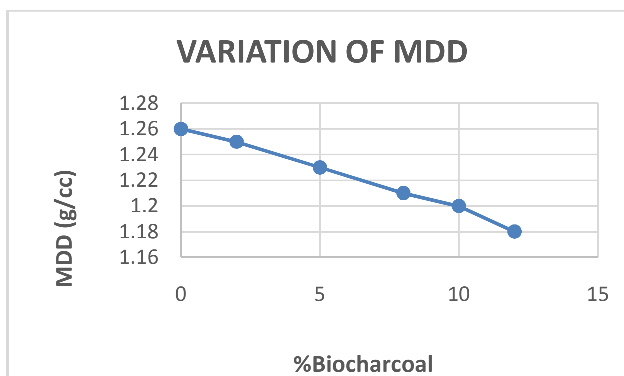

Fig 3 Variation of maximum dry density

B. Atterberg limits

Atterberg's limit test was performed as per IS: 2720 (Part 5) 1985. Soil sample passing through 4.25 mm IS sieve was used to determine liquid limit, plastic limit, and plasticity index characteristics. Variation of Atterberg's limit with the addition of biochar and soil was also studied.

Bentonite was treated with varying percentages of biochar such as 2%, 4%, 6%,8% and 12%. The test result indicates the liquid limit decreases and plastic limit increases.

The decrease in liquid limit on increasing the biochar content due to reduction in thickness of diffused double layer and absorption of water content by biochar.

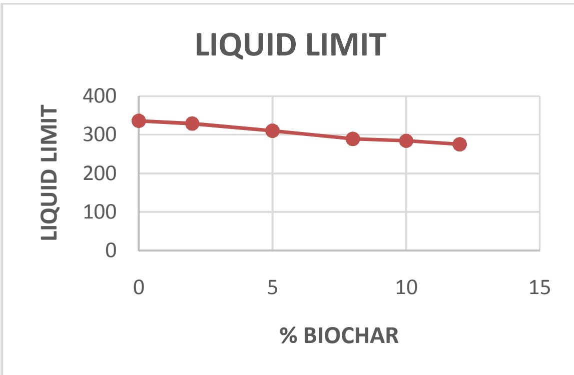

Fig 4 Variation of liquid limit

When biochar was added into soil, the plastic limit increased. The variation of plastic limit is shown in the Fig 4. Plastic limit increases with increase in dosages of biochar due to the reaction adduced by liquid limit.

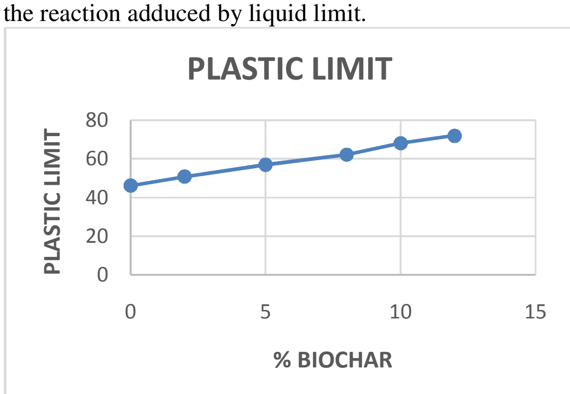

Fig 5 Variation of plastic limit .

When biochar was added into soil, the plasticity index is reduced. This reduction is due to decrease in liquid limit and increase in plastic limit.

C. Effect on Nano silica on UCS on soil mixtures

Effect of biochar on the soil with different dosages shows that the compressive strength increases with increase in the dosage of the biochar. Fig 6 represents the UCS results for samples It can be observed that the increase in dosage of biochar increases the UCS value, which is an indication that the biochar causes a change in the behavior of the soil mass by producing greater bonding between the soil particles. At constant moisture content, due to the absorption of water by biochar, the clay became less compressible, which was worsened with increasing biochar content. This may be the reason for the reduction in the peak strength of stabilised clay with 12% biochar in comparison with clay stabilised with10% biochar. It is clear from Figure 6 that the increase in the UCS of stabilised clay occurs at lower strain in all specimens compared with the natural clay.

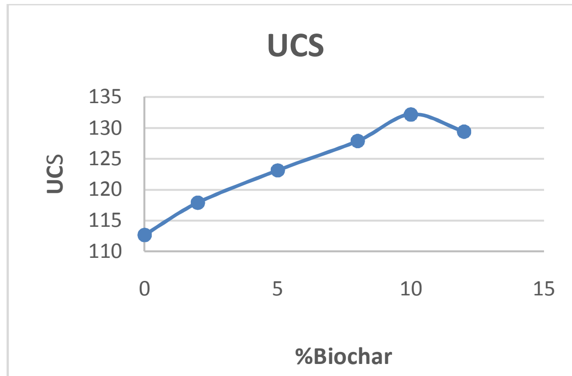

Fig 6 Variation of unconfined confined compressive strength

V. CONCLUSION

- Liqiud limit decreases and plastic limit increases. Thereby the plasticity index decreases. A further increase in additive percentage beyond optimum causes reduction in overall rate of PI of stabilised soil.
- Addition of biochar leads to an increase in water absorption and a reduction in pores between clay particles, resulting in a decrease in the maximum dry unit weight andincrease in optimum moisture content of soil.
- The biochar has a positive influence on the stiffness of treated specimens. The addition of biochar to clay causes a reduction in failure strain of the specimens compared with untreated clay.
- At the optimum level of 10%, the biochar provides a stiff particle network to carry applied stresses while the clay particles fill void spaces and hold the specimen together.
- Increasing past this optimum percentage heighten the risk of void space between biochar material while reducing the effectiveness of the soil's cohesive properties, resulting in weaker, brittle mixtures.

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