Improvement of bearing capacity of clay that is stabilized with bamboo charcoal powder

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Abstract. A building construction must be built on the soil with good bearing capacity. Increasing of bearing capacity of the soil can be done by adding material of soil stabilizer. Bamboo charcoal powder was used in this study as a stabilizer for clay. The percentage of the addition of bamboo charcoal powder to clay soil in this study was 5%, 10%, and 15%. The California Bearing Ratio (CBR) test was carried out on original clay and stabilized clay to determine the bearing capacity of the soil. The results of this study as showed an increase in the CBR value of each percentage of the addition of bamboo charcoal powder. The highest CBR value was the addition of 15% bamboo charcoal powder with an increase in the CBR value of the original clay by 82.87%. The increase in the CBR value of the soil indicates that there is an increase in the bearing capacity of the clay due to the addition of bamboo charcoal powder.

1. Introduction
The bearing capacity of soil is the ability of the soil to support the load on it. Soil with low bearing capacity cannot support the load of building construction. One of the parameters needed to determine the condition of the soil is the value of CBR (California Bearing Ratio). In planning the pavement, the value of the bearing capacity of the subgrade is needed to determine the thickness of the pavement. Soil CBR value can indicate the bearing capacity of soil [1]. To evaluate the potential strength of subgrade, subbase, and base course material, including recycled materials for use in pavements, the CBR test method was used [2].

Soft clay is soil with a low bearing capacity. To increase the strength of the soil, it is necessary to carry out an effort to stabilize the soil. A method of improving the shear strength parameters of soil and thus increasing the bearing capacity of soil by blending and mixing other materials namely soil stabilization [3], [4], [5]. Classification of ground modification techniques is the mechanical modification, hydraulic modification, physical and chemical modification [6]. Chemical stabilization is done by mixing other materials with soil so that a chemical reaction occurs between the soil and the mixing material, which will produce new materials that have better soil properties.

In Indonesia, various types of bamboo are spread all over Indonesia. Bamboo is a versatile plant that almost all of its parts can be used for human needs. In the construction, bamboo charcoal powder is used as a material for soil stabilization to improve soil properties [7], [8], [9]. The bamboo charcoal powder contains carbon. The addition of carbon to clay can improve soil characteristics such as the value of atterberg limit, unconfined compression strength, and CBR value [10].

Based on the description above, the bamboo charcoal powder was used in this research as a soil material stabilization. CBR testing was carried out on a mixture of bamboo charcoal powder and clay.
This research aims to determine the effect of adding the bamboo charcoal powder to CBR value. From the test results can be obtained an analysis of the bearing capacity of the soil.

2. Method

2.1. Soil

The sample of this research from Reklamasi Village, Air Jangkang Merawang, Bangka is soft soil. A series of an experimental test of soil was conducted in the laboratory. Laboratorium tests were done on the sample according to Indonesia National Standards (SNI). Based on the USCS method of soil classification, the sample of this research is classified in Inorganic Clays with low plasticity (CL). Index properties of soil as given in Table 1.

| Table 1 Index Properties of Soil |
|---------------------------------|
| Specific Gravity (GS) | Natural Moisture Content (W) | Liquid Limit (LL) | Plastic Limit (PL) | Maximum Dry Density (MDD) | Optimum Moisture Content (OMC) |
| gr/cm³ | (%) | (%) | (%) | gr/cm³ | (%) |
| 2.63 | 31.83 | 35.68 | 20.46 | 1.76 | 18.3 |

2.2. Bamboo Charcoal Powder

In this research, the bamboo charcoal powder was the material used as an additive for soil stabilization. Bamboo charcoal powder ware took from the manual combustion process, the steps for preparing bamboo charcoal powder:

1. The bamboo that has been provided ware dried until the color of the bamboo turns yellow.
2. The bamboo was burned for 10 days in the kiln.
3. After that, the bamboo cooling process was carried out for 10-14 days.
4. Next, the finished bamboo charcoal was pounded using a rubber mallet and sieved with a sieve shaker.

Original clay was mixed with bamboo charcoal powder, it uses water with optimum moisture content based on soil compaction results testing, as given in table 1. Bamboo charcoal powder mixed into original clay with varying levels of 5%, 10%, and 15% of the dry weight of the soil. The mixture variation of this research is given in table 2. The process of mixing material is shown in figure 1. Furthermore, a California Bearing Ratio (CBR) test ware carried out on the original clays and stabilized clays.

| Table 2. Mixture Variation |
|---------------------------|
| No | Mixture Variation. | Number of Sample |
| 1 | Clay | 6 |
| 2 | Clay + 5% Bamboo Charcoal Powder | 6 |
| 3 | Clay + 10% Bamboo Charcoal Powder | 6 |
| 4 | Clay + 15% Bamboo Charcoal Powder | 6 |

Figure 1. Samples Preparation For CBR Testing (a) Clay (b) Bamboo Charcoal (c) Mixing (d) Compaction
2.3. California Bearing Ratio
California Bearing Ratio (CBR) is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material.

\[
\text{CBR} = \left(\frac{PT}{PS}\right) \times 100
\]

\(PT = \) Corrected test load corresponding to the chosen penetration from the load penetration curve.
\(PS = \) Standard load for the same penetration

CBR testing was carried out on the original clay and clay that had been stabilized with bamboo charcoal powder. In this study, CBR testing was carried out under soaked conditions using guidelines based on SNI 1744:2012 carried out with 3 (three) types of blow namely 10, 30, and 65 blow. The CBR soaked testing is carried out after the compaction test is completed. After being compacted, the sample was soaked for 4 (four) days and the value of its development was observed only after which the CBR test was carried out. The results of the test are then displayed in the figures. Then the results of the test were compared with the respective percentages of 5%, 10%, and 15% of the addition of bamboo charcoal powder. The process of CBR Testing is shown in figure 2.

![Figure 2. The Process of CBR Test](image)

(a) Mixing The Sample (b) Soaking The Sample (c) CBR Test

3. Results
CBR test was carried out on original and mixed clay. The result of the CBR test on each variation, namely Clay, Clay with 5% Bamboo Charcoal Powder (BCP), Clay with 10% Bamboo Charcoal Powder (BCP), and Clay with 10% Bamboo Charcoal Powder (BCP) show in figure 3.

![Figure 3. The Effect Of Adding Bamboo Charcoal Powder To CBR Value](image)

From figure 3 CBR value is increasing with increasing levels of bamboo charcoal powder sequentially such as 4.15%, 4.94%, 5.93% and 8.49 % in 10 blows; 6.12%, 7.70%, 8.89% and 10.47% in 30 blows; 6.91%, 9.88%, 10.67%, and 12.64% in 60 blows . The more bamboo charcoal powder in the soil mixture causes the CBR value increase. The presence of large carbon content in bamboo charcoal powder can increase the CBR value [10]. The highest increase in the CBR value of the original
clay is the addition of 15% bamboo charcoal powder in 60 blows with a percentage increase of 82.87%. The increase in CBR value also occurs with the increase in the number of blows in the CBR test. The more the number of a blow, water in the soil cavity will come out more and the air cavity will get smaller than the density of the soil increases, thereby increasing the CBR value.

There is a strong linear correlation between the estimated ultimate bearing capacity and the corresponding CBR value [11]. The density and cohesion of soil are directly proportional to CBR because the soil particles become more compact to carry more loads or stresses [12], [13]. The increasing CBR value of the soil indicates that the bearing capacity of the soil is increasing.

4. Conclusion

The conclusion of this research is based on the result of the soil test laboratory that the addition of bamboo charcoal powder in the clay can increase the value of California Bearing Ratio, with increasing level of bamboo charcoal powder to a content of 15%. It can be concluded that the addition of bamboo charcoal powder can improved the bearing capacity of the soil.

References
[1] Ekeocha N E and Egesi N 2014 J Appl Sci Environ 18 pp 185
[2] American Society for Testing and Materials (ASTM, D1883–07) 2007
[3] Afrin H 2017 International Journal of Transportation Engineering and Technology 3 19-24
[4] Firoozi A A, Olgun C G, and Baghini C G 2017 Geo- Engineering 8 2-16
[5] Njideka O and Ben N 2018 IOP Conf. Series Materials Science and Engineering 413 012023
[6] Hausmann M R 1990 Engineering Principles of Ground Modification (Singapore: McGraw-Hill)
[7] Ramya V, Sowmiya S, and Karthickeyan S 2018 International Journal of Innovative Research in Science Engineering and Technology 7 pp 144-149
[8] Wijaya W, Ismanti S and Rifa’i A 2020 Journal of Physics: Conference Series 1625 012007
[9] Chandran N and Vijayan V 2017 Engineering Research & Technology (IJERT) 2 505-509
[10] Al-Soudany K, Al-Gharbawi A and Al-Noori M 2018 MATEC Web of Conferences 162
[11] Purwana Y M and Nikraz H 2013 International Journal of Transportation Engineering 1 211-222
[12] Yashas S R, Harish S N and Muralidhara H R 2016 Journal of Engineering Research (AJER) 5 28-37
[13] Li T, Kong L and Liu B 2020 Appl. Sci. 10 7576

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