The Effect of Addition of Bagasse Ash and Eggshell Powder on CBR Value of Clay Soil

M Carlina, Y Apriyanti* and F Fahriani
Department of Civil Engineering, Universitas Bangka Belitung, Indonesia

*E-mail: yayukapriyanti26@gmail.com

Abstract. In the construction of road construction, soil bearing capacity, such as the CBR value, needs to be considered. In clay soil, the CBR value of the soil is low, so that stabilization material can be added to its repair. In this study, the stabilization materials used were waste materials in the form of bagasse ash and eggshell powder. Variations in the mixture of bagasse ash mixture used in this study were 7%, 10%, and 13% plus 3% eggshell powder. Testing in this study includes testing moisture content, sieve analysis, specific gravity, consistency limits, compaction testing, and CBR. The soil classification system used is the Unified classification (USCS), a test guideline based on SNI. From the CBR soaked test, it was found that the CBR value of clay soil increased along with the increase in the percentage of bagasse ash plus 3% eggshell powder and the increase in collisions on the soil. The percentage increase in the CBR value of clay soil with a mixture of stabilization to clay soil is 92.303%. at 65 blow. So that bagasse ash and eggshell powder greatly affect the increase in the CBR value of clay soil.

1. Introduction
The bearing capacity of the soil is an important component in infrastructure development such as road construction because the soil is the basis on which the foundation is laid and determines the strength of the foundation so as not to cause damage or even failure to the structure of the building above it. The soil must have a high bearing capacity because all the loads in the structure will gather on the foundation. Soil problems that occur include when the soil has a low bearing capacity such as clay soil which can be viewed from the CBR (California Bearing Ratio) value. The CBR value will be low if the bearing capacity of the soil is low and to improve it can be done by mixing the soil with stabilizing material. This stabilizing material can be in the form of a chemical mixture, waste, or other materials that can increase the bearing capacity of the soil [1].

In Pangkalpinang, Bangka Belitung Islands Province, Indonesia, waste from bagasse and eggshells has not been widely used. If the waste from sugar cane is utilized, one of the environmental problems can be overcome [2], as well as waste from eggshells [3]. Several previous studies have proven that bagasse can be used as a soil stabilizing agent such as in subgrade it can increase the unsoaked CBR value [4] in black cotton soil can increase the CBR value and soil density [5], bagasse ash can also be mixed with other stabilizing materials such as lime to increase the strength of expansive soil [6]. Bagasse ash can be used as a stabilizing agent because bagasse ash contains high silica, calcium, and other minerals. [7].
The eggshell powder has also been used as a stabilizing agent in several previous studies such as organic silt and organic clay with low plasticity (OL) mixed with eggshell powder to increase the dry weight value of the soil [8]. The Eggshell powder can also be mixed with other stabilizing agents such as fly ash applied to black cotton soil to increase the maximum dry density of the soil [9] and the CBR value of the soil [10]. In another study, eggshell powder mixed with quarry dust as a stabilizing agent can increase the value of angle of internal friction and shear strength of sandy soil [11]. The Eggshell powder mixed with coir fiber in soil stabilization can withstand a greater load [12]. Eggshell powder can be used as a stabilizing agent because its composition and chemical properties are almost the same as that of lime [13].

Table 1. Chemical content of eggshell Powder (ESP) [14]

| Chemical content | Result (%) |
|------------------|------------|
| Density (gr/cm³) | 2.47       |
| K                | 12.0       |
| Ca               | 50.2       |
| Mg               | 12.0       |
| Al               | 0.0        |
| H + Al           | 0.0        |
| Na               | 21.0       |

Table 2. Chemical content of Bagasse Ash (BA) [15]

| Chemical compound | Result (%) |
|-------------------|------------|
| SiO₂              | 50.36      |
| K₂O               | 19.34      |
| CaO               | 8.81       |
| TiO₂              | 0.26       |
| P₂O₅              | 0.51       |
| MnO               | 0.68       |
| Fe₂O₃             | 18.78      |
| CuO               | 0.15       |
| ZnO               | 0.15       |

In this study, bagasse ash was obtained from the burning of bagasse in beverage products from sugarcane juice whose waste was not optimized so that the waste became a lot and piled up, eggshell powder was the result of drying eggshells that were pounded into powder. The eggshells obtained are also the result of waste in the bread-making industry in the city of Pangkalpinang.

2. Research Method
This research is in the form of an experiment in a laboratory, starting with a literature study and also continuing with a survey at the sampling location. The next research preparation is the preparation of materials and testing equipment. This test uses clay soil originating from the Mangrove Forest of Sawah Village, Muntok District, West Bangka Regency, Bangka Belitung Islands Province.

The bagasse stabilization material is burned by a manual process, namely by putting it in a canned drum and then burning it until it turns into ashes. Meanwhile, The eggshell powder is produced by
pounding eggshells into fine grains. Bagasse ash and eggshell powder used are passed filter no. 10 and retained in filter no. 40.

The test carried out is the field water content test, sieve analysis, specific gravity, Atterberg limits, compaction, and CBR. This test uses Indonesian National standards [16] and soil classification using the USCS (Unified Soil Classification System) system. The data generated on the soil classification is the data generated from the Atterberg limits test and also sieve analysis. The compaction test used the modified Proctor method. The data generated in this compaction test is the data of the optimum moisture content (OMC) and also the maximum dry density (MDD) value which is then used in the soaked CBR test as shown in Figure 1. The percentage of bagasse ash (BA) used was 7%, 10%, and 13% of the dry weight of the soil and the percentage of eggshell powder (ESP) used was 3% of the dry weight of the soil.

![CBR Samples Soaking Process](image1) ![CBR Test](image2)

**Figure 1. CBR Soaking and Testing**

3. Results

Based on soil properties testing, the soil moisture content values in the field, sieve analysis, specific gravity, Atterberg limits were obtained which are shown in Table 3.

| No. | Test                                    | Unit | Result Test |
|-----|-----------------------------------------|------|-------------|
| 1   | Field Water Content                      | %    | 32.858      |
| 2   | Sieve Analysis, soil loose sieve no. 200 | %    | 59.6        |
| 3   | Liquid Limit                             | %    | 33.27       |
| 4   | Plastic Limit                            | %    | 21.776      |
| 5   | Plastic Index                            | %    | 11.494      |
| 6   | Specific Gravity                         | -    | 2.637       |

From Table 3, the sieve analysis data, liquid limit, plastic limit, and plasticity index are used for soil classification with the USCS system, the results obtained are that clay is included in the CL category, where this clay has a low level of plasticity. Compaction test obtained the optimum moisture content of 24.9% and the maximum dry weight of the soil of 1.569gr/cm³.
Figure 2. The relationship between the CBR value and blows from the sample variation at 0.1 inch penetration.

Based on data shown in Figure 2, shows that the CBR value of clay has increased when mixed with 7%, 10%, 13% bagasse ash (BA), and 3% eggshell powder (ESP). The CBR value increased with the increase in the amount of bagasse ash content. The CBR value of clay at 65 blows experienced an increase in the percentage of 92.303% from the original clay by 6.518% to 12.533% in the variation of clay mixed with 13% bagasse ash (BA) and 3% eggshell powder (ESP). The increase in CBR value in clay is caused by the influence of silica content contained in bagasse ash and calcium in eggshell powder. This causes silica which can bind water with clay to make the bond stronger and also eggshell powder with a coarse category containing calcium which can have an impact on increasing the bearing capacity of the soil because the clay has been filled densely with eggshell powder and the silica in bagasse ash has been binding water in it and is pozzolanic.

The results of this study can add a reference that the bearing capacity of clay soil can be increased by the addition of bagasse ash with eggshell powder so that bagasse ash mixed with eggshell powder can be recommended as a soil stabilizing agent.

4. Conclusion
The CBR value in the original clay increased with the increase in the percentage of bagasse ash mixture. The CBR value of the original clay for 65 blows was 6.518%, increased to 12.533% in the variation of clay with a mixture of 13% bagasse ash (BA) and 3% eggshell powder (ESP). From the results of this study, it can be added that the bearing capacity of clay soil can be increased by adding bagasse ash with
eggshell powder so that bagasse ash mixed with eggshell powder can be recommended as a soil stabilizing agent.

References
[1] Bowles J E1984 Physical and Geotechnical Properties of Soils (US:McGraw-Hill Inc).
[2] Reddy T S and Prasad S V 2017 Stabilization of Soil Using Sugarcane Straw Ash and Polypropylene Fibres Int. J of Eng. And App. Sc 4 5-8
[3] Prasad K, James P P, Mathachan N and Justine T L 2016 Effect of Curing on Soil Stabilized with Egg Shell Int. J of Science Technology & Engineering 2 259-264
[4] Pachori C and Saxena A 2019 Stabilization of Subgrade Soil Using Sugarcane Bagasse Ash (SCBA) Int. Res J of Eng and Tech 6 1485-1490
[5] Shringi S, Khatti J and Acharya B 2019 Stabilization of Black Cotton Soil by Using Sugarcane Bagasse Ash Int. J. of Sci. Res. And Rev. 7 127-132
[6] Murali K, Ashok S, Giridharan N, Pandiarasan Kaniyan K and Logesh P 2018 A Review on Stabilization of Expansive Soil with Various Admixtures Int. J. of Sci and Res. Pub. 8 214-217
[7] Gandhi K S, Expansive Soil Stabilization Using Bagasse Ash Int. J of Eng. Res & Tech. 1 pp 1-3
[8] Wong I L K 2016 Study Added of Waste Chicken Egg Shell in Soils Int. J of Str. And Civ. Eng. Res. 5 207-211
[9] Pavani S D R I and Mangamma V A Stabilization of Black Cotton Soils Using Flyash & Egg Shell Powder Int. J. of Mod. Tren in Eng. And Res. 130-134
[10] Birkur S K 2019 Stabilization of Black Cotton Soil by Fly Ash and Egg Shell Powder Iconic Res. and Eng. J. Dep. of Civ. Eng. 3 8-12
[11] Sahu G, Kumar I, Singh A and Gupta D 2017 Studies on Improvement of Shear Strength of Sandy Soil Using Egg Shell Powder and Quarry Dust Int. J. of Eng. Res. & Tech. 6 440-443
[12] Sourav and Sonthwal V K 2021 Soil Stabilization Using Eggshell Powder and Coir Fiber Int. Res. J. of Mod. In Eng. Tech. and Sci 3 615-618
[13] P Anoop S, Beegom H, Johnson J P, J Midula, N Tharis Muhammed T and S Prasanth 2017 Potential of Egg Shell Powder as Replacement of Lime in Soil Stabilization Int. J. of Adv. Eng. Res. and Sci 4 86-88
[14] Munirwan R P, Munirwansyah, and Marwan 2019 Penambahan Serbuk Cangkang Telur Sebagai Bahan Stabilisasi Pada Tanah Lempung, J Teknik Sipil 8 30-35
[15] Yusuf M, Suhendar D and Hadisantoso P 2014 Studi Karakteristik Silika Gel Hasil Sintesis Dari Abu Ampas Tebu DenganVariasiKonsentrasi Asam Klorida J Istek 8 16-28
[16] Badan Standar Nasional 2008 Standar Nasional Indonesia Pengujian Tanah

Acknowledgments
We gratefully acknowledge the funding from Universitas Bangka Belitung through the RKAKL FT for the publication of this paper.