Experimental Study on CBR Value of Overboulder Asbuton Stabilized by Cement

Noor Dhani, Lawalenna Samang, Tri Harianto, and A. R. Djamaluddin
Hasanuddin University, Indonesia
Email: noordhanitech@gmail.com, l_samang@yahoo.com, triharianto@ymail.com, jamaluddin_abdulrahman@yahoo.co.id

***Abstract*— The load capacity of a material as a road foundation expressed in CBR values. The low CBR value became a problem in many countries for road construction. Buton Island in Southeast Sulawesi, Indonesia, has large amount about 627 million metric tons of asphalt deposit in many forms. In Indonesia, natural asphalt derived from Buton Island was called Asbuton (Asphalt Buton). The Asbuton deposit divided to several type. One of the types is overboulder which about 30% of total deposit of asbuton. Overboulder occurred naturally when limestone reacts with bitumen in top soil layer of asbuton itself, made it a waste material which could be used as stabilizer material, due to its lime content with low bitumen content at about below 2%. Recently in Indonesia, asbuton in general started to be studied for either stabilization and asphalt content extraction. In this research, overboulder is used as replacement material for road foundation layer, stabilized with 3%, 5%, 7% and 10% cement based on the dry density of the overboulder to gain higher bearing capacity. The tests are carried out using CBR specimens with curing time of 7 and 28 days. The test results showed that the addition of cement significantly affected the CBR value. The addition of 10% cement increases the CBR value of the overboulder by 6.8 times, which equals to 82.5% after 28 days of curing time. This CBR value is greater than the addition of 3%, 5% and 7% cement. With this result, overboulder can be used as replacement material for pavement foundation layer which has a high CBR value. And by using local content, there is a chance for advantages both technically and financially for upcoming development, especially in Southeast Sulawesi.**

***Index Terms*— California Bearing Ratio (CBR), overboulder asbuton, cement**

I. Introduction

A soil or aggregate treated with a relatively small proportion of portland cement with the objective of amending undesirable properties of problem soils or substandard materials so that they are suitable for use in construction. The amount of cement added to the soil is less than that required to produce a hardened mass, but enough to improve the engineering properties of a soil (for example, plasticity index reduction, bearing strength improvement) [1].

The pozzolanic reaction process, which can either be modest or quite substantial depending on the mineralogy of the soil, is a long term process. The pozzolanic reaction progresses relatively quickly in some soils depending on the rate of dissolution from the soil matrix. In fact, physio-chemical changes at the surface of soil particles due to pozzolanic reactions result in changes in plasticity, which are reflected in textural changes that may be observed relatively rapidly just as cation exchange reactions are [2].

For different types of soil, a guideline for stabilisation has issued specifying the Plasticity Index (PI) of sandy soil to be less than 30. For fine grain soil PI should not be more than 20 and to ensure proper mixing liquid limit (LL) should not be more than 40. [3] Soil-cement is an engineered material designed and constructed for various pavement applications or material characteristics. The best soil-cement product is the one best suited to the specific application. Soil-cement is frequently used as a construction material for pipe bedding, slope protection, and road construction as a sub base layer reinforcing and protecting the subgrade. It has a good compressive strength, so it is prone to cracks [4].

A cement-modified soil contains relatively small proportions of Portland cement. The result is caked lightly harden material, similar to a soil, but with improved mechanical properties, lower plasticity, increased bearing ratio and shearing strength, and decreased volume change. [5] Cement is the oldest binding agent since the invention of soil stabilization technology in 1960's. It may be considered as primary stabilizing agent or hydraulic binder because it can be used alone to bring about the stabilizing action required [6]. As defined in ASTM specification C618-78, pozzolans are siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. In addition to reacting with Ca $(OH)^2$, pozzolans react also with C_3A or its products of hydration. [7]

Overboulder asbuton dominated by calcium content of 79.64% and silicon content of 9.63%, so that in the composition contained by these minerals can be used as pozzolanic material that can function as a binder and filler from soft soil material that can increase the bearing capacity of the material.[8] Different testing procedures

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have been applied in various studies, which made comparison difficult. However, compressive strength and durability were the two major approaches made, with the Americans more inclined towards durability technique. Other techniques employed were California bearing ratio, tensile and flexural tests [9]. The required specifications for sub-base and road-base, given in the Technical Specification booklet of different road projects, are described by the following items: grading, Atterberg limits, CBR, aggregate crushing value (ACV), ten percent fines value, bulk specific gravity, water absorption [10].

II. Research Methodology

In order to classify the material used in this experimental study, laboratory investigation program was carried out to evaluate the basic properties and mechanical properties of the untreated soil and stabilized soil, in this case, overboulder stabilized by cement. Overboulder was stabilized using cement with percentage based on the dry density of each mix. The mix used in this study is described as follows:

TABLE I. Mix Design CBR Overboulder Stabilized with Cement

Overboulder (%)	Cement (%)	Curing	
		7 Days	28 Days
97	3	3	3
95	5	3	3
93	7	3	3
90	10	3	3

Figure 1. Overboulder sample visual

The asbuton overboulder material was brought from Buton Island and sampled at Lawele with coordinate 5 ° 13'53.56 "S and 122 ° 58'0.40" E. Cement is used as binding material to increase cohesion between overboulder grains and increases the bearing capacity. The amount of cement mixed to overboulder was based on the dry density of each mix obtained from standard proctor test. Specimen tested in 7 days and 28 days of curing time. California Bearing Ratio specimen was remolded according to standard method ASTM D 1883-07 with 6 inches in diameter and 7 inches high.

Figure 2. Overboulder quarry location

III. Results and Discussion

The results of the basic properties and mechanical properties of overboulder are shown in the following table.

TABLE II. Recapitulation of Basic Properties and Mechanical Properties of Overboulder

Test	Result
Specific Gravity (Gs)	2,65
Sieve Analysis	
Sand Fraction	81,04 %
Silt Fraction	13,70 %
Clay Fraction	5,16 %
Standard Proctor	
Max Dry Density (γdry)	1,37 gr/cm ³
Optimum Moisture Content	19,13 %
Soil Classification	USCS : SP
	AASHTO : A – 1 - b
CBR Unsoaked	12,06 %

According to the USCS (Unified Soil Classification System), overboulder was classified as SP-SM, ie, poorly-graded sand with 81,04% sand fraction, 13,70% silt fraction, and 5,16% clay fraction. While, according to AASHTO, overboulder was classified as type A-1-B with an estimation of quality poor to fair. The untreated overboulder reach CBR value of 12,06%.

The compaction test is an attempt to achieve maximum soil density with standard energy in order to determine the soil density based on the weight of the dry soil and the optimum water content of the soil. The following is a graph of the relation between moisture content and dry density of the untreated and stabilized overboulder sample.

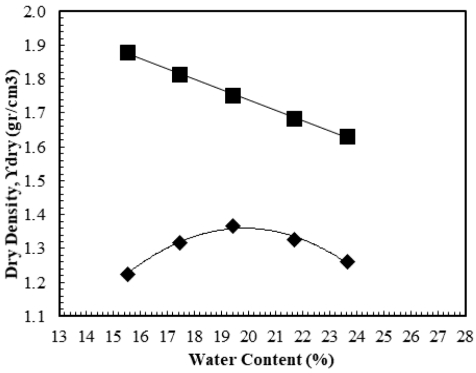

Figure 3. Relation between dry density and moisture content of untreated overboulder

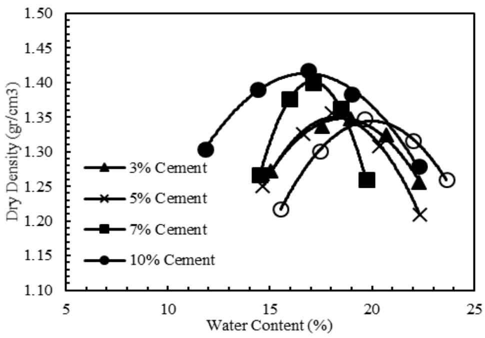

Figure 4. Relation between dry density and moisture content of overboulder with cement variations

Based on the result of the standard proctor test, the optimum moisture content, Wopt = 19.43% and the maximum dry density, γ dmax = 1.37 gr / cm^3. The curve of the relation between moisture content and dry density determined the value of water addition to the preparation of CBR sample. Standard proctor test result shows that by adding more cement into the mix, dry density decreases while the optimum moisture content decreases.

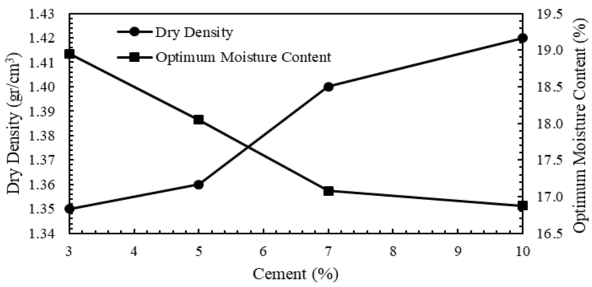

Figure 5. Relation between optimum moisture content, dry density and cement addition

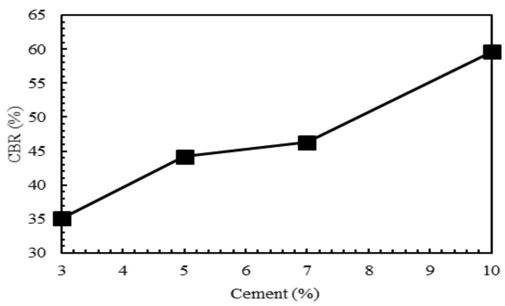

Figure 6. CBR result on 7 days of curing time

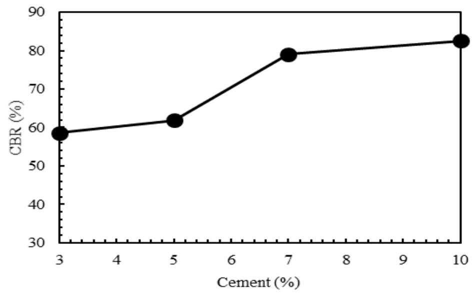

Figure 7. CBR result on 28 days of curing time

At 7 days of curing time, the CBR test result has shown improvement. The CBR value increases compared to untreated overboulder and increasing as more cement added to the mix. The highest CBR value at 7 Days of curing time reaches 59,57% or 4,9 times compared to untreated overboulder.

At 28 days of curing time, the CBR test result has shown even more improvement. The CBR value increases and reaches 82,50% or 6,7 times compared to untreated Overboulder. This value even higher than 7 days of curing time. To be spesific 1,3 times compared to the highest CBR value at 7 days of curing time.

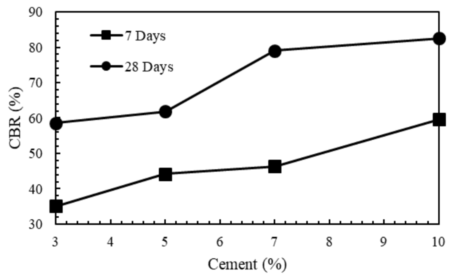

Figure 8. CBR result on certain curing period

TABLE III. RECAPITULATION OF CBR TEST RESULT

Mix	CBR (%)	
	7 Days	28 Days
Overboulder + 3% Cement	35.07	58.6
Overboulder + 5% Cement	44.21	61.84
Overboulder + 7% Cement	46.31	79.05
Overboulder + 10% Cement	59.57	82.5

From the result of the test, it can be concluded that the more cement added to the overboulder, the higher CBR value become. And the more curing time given, the pozzolanic reaction become more stable and give the overboulder more stiffness, proofed by increasing CBR value. As result, overboulder stabilized by cement might be a solution for road foundation problems, especially in the potential area as utilization of local material.

IV. CONCLUSION

Based on laboratory test and analysis of the data, we can conclude that cement addition to overboulder can increase CBR value significantly up to 6, 7 times compared to untreated overboulder. In order to increase CBR value, it is necessary to let the cement and overboulder reacts, and harden by giving curing time needed. In general, overboulder asbuton was considered as one of proper material for pavement foundation. And by using local deposit, there is a chance for advantages both technically and financially for upcoming development, especially in Southeast Sulawesi.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The result of this research won't be achieved without cooperation from the authors. Noor Dhani prepared the materials, and responsible for the technical aspects. The rest of the authors analyze the data and write the manuscript.

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Noor Dhani was born on August, 26 1966. He is currently a doctoral student at Hasanuddin University, Indonesia. His study was mostly interested in Geotechnical Engineering. He gains his undergraduate degree at Hasanuddin University as well as his master degree. He also actively joins in some professional organization namely Chairperson of the Indonesia Bau Bau City Construction Company Association, deputy Chairperson of the Association of Indonesian Construction Companies in Southeast Sulawesi, Chairman of GMPK - Community Movement Against Corruption Buton Regency, and Deputy Chairperson of the Indonesian Association of Construction Experts in Southeast Sulawesi.

Lawalenna Samang was born on December, 31 1960. He was a Professor in affiliation with Hasanuddin University. His research interest was mostly Geotechnical Engineering, Geo-Environmental Engineering, Soil Improvement, and Cyclic Loading on Soft Soil. Some of his published works are "Partially-drained cyclic behavior and its application to the settlement of a low embankment road on silty-clay, The Japanese Geotechnical Society, 2003","Motorcyclist acceptability on road safety policy: Motorcycle exclusive lane in Makassar, Proceedings of the Eastern Asia Society for Transportation Studies, 2013", "Characteristic analysis of unconfined compressive strength and CBR laboratory on dredging sediment stabilized with Portland cement, International Journal of Civil & Environmental Engineering IJCEE-IJENS, 2012", "Noise Level Study Based On Traffic Characteristics, Physical And Environmental Aspects Of Road, International Journal Of Civil Engineering And Technology (IJCIET), 2016", and "Microstructural and Mechanical Characteristic of Potential Ferro Laterite Soil as Sub-base Material, International Journal of Innovative Research in Advanced Engineering (IJIRAE), 2016". He also has professional awards, namely Satyalencana Karya Satya Honor, and Professional Engineer by Indonesian Society of Geotechnical Engineer (HATTI). He started his Undergraduate Study at Civil Engineering Departement Hasanuddin University, Indonesia, 1984. Master Degree and Doctoral Degree at Saga University Japan, focusing on Geotechnical Engineering in 1994 and 1997.

Tri Harianto was born on March, 9 1972. He currently signed as Associate Professor in Hasanuddin University. His research interests are mostly Geotechnical Engineering and Soil Improvement. Some of his published works are "Experimental Study of Soft Soil Reinforcement with Geogrid Artificial Granular Column, International Journal of Civil Engineering and Technology, 2019", "Airside Development at Oesman Sadik Airport, South Halmahera District, International Journal of Innovative Technology and Exploring Engineering, 2019", "Interpretation of CBR Test Results Based on the Rapid Impact Compaction Electro-Mechanic System Model, MATEC Web of Conferences, 2018", "Bearing Capacity Characteristic of Subgrade Layer Quicklime Treated Laterite Soil, MATEC Web of Conferences, 2018", and "The Compressive Strength Improvement on Soft Soil Subgrade with Quicklime Stabilization, Activated Gum Rosin and Iron Oxide, MATEC Web of Conferences, 2018". He started his Undergraduate study at Civil Engineering Dept, Hasanuddin University, Indonesia. Master Degree at Sepuluh November Institute of Technology, Indonesia. Doctoral degree focused on Geotechnical Engineering at Saga University, Japan.

Abdul Rachman Djamaluddin was born on October, 10 1959. He currently signed as Associate Professor in Hasanuddin University. His research Interests are mostly about Geotechnical Engineering, Soil Improvement and Material Science. Some of his published works are "1. Abrasion resistance and compressive strength of unprocessed rice husk ash concrete, Asian Journal of Civil Engineering, 2018", "Corrosion behavior of reinforcing steel bar embedded in concrete with nickel slag coarse aggregates, International Journal of Civil Engineering and Technology, 2018", "Formulation of method of reinforced concrete column design using quadratic polynomials, International Journal of Civil Engineering and Technology, 2018", "Effect of hydrated lime on compressive strength mortar of fly ash laterite soil geopolymer mortar, IOP Conference Series: Materials Science and Engineering, 2017", and "Design of reinforced areas of concrete column using quadratic polynomials, IOP Conference Series: Materials Science and Engineering, 2017". He started his Undergraduate degree at Civil Engineering Dept, Hasanuddin University. Continue his Master degree at Sepuluh November Institute of Technology and his Doctoral degree at Civil Engineering Dept, Hasanuddin University. He also actively participated in training events such as Soil-Structure Interactions and Geotechnical Considerations on Foundation of High-Rise Building Workshop, in 2007 and Confrenrece of Lowland Technology, Japan, in 2011.