Journal of Advanced Research in Applied Mechanics 135, Issue 1 (2025) 117-127

Journal of Advanced Research in Applied Mechanics

Journal homepage:
https://semarakilmu.com.my/journals/index.php/appl_mech/index
ISSN: 2289-7895

Testing the Characteristics and Composition of Sirtu and Asphalt Buton on Soft Soil

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ARTICLE INFO

Article history:
Received 15 February 2025
Received in revised form 22 March 2025
Accepted 29 March 2025
Available online 30 April 2025

Keywords:
Sirtu; asbuton; CBR; soft soil

ABSTRACT

The test piece utilized is inside the outline of a barrel with an estimation of H=2D, made by mixing Asbuton, sirtu. The materials utilized in this consider include of two sorts of materials, to be particular sirtu texture which is utilized as the elemental texture of the column and asbuton which is utilized as a filler as well as a folio. As has been clarified, testing texture characteristics consolidates: physical properties and mechanical properties. The examination inside the sirtu Materials Inquire about office was ruled by the shake division of 82.48%. With reference to the Bound together Soil Classification System, the sirtu utilized in this consider is classified as GW, to be particular Sandy Shake with extraordinary degree, since the CU regard is 5.16 and CC is 1.29 with little/no fine-grained soil.

1. Introduction

In general, the problem with buildings on soft soil is friction. The mechanism of loss of balance occurs in soils whose bearing capacity is low due to the high load on the soil itself. Another problem that usually arises is a lump [1]. This often occurs in clay and silt layers due to differences in water pressure and can also cause settlement. Increasing the bearing capacity of the soil can be achieved by changing the properties of the soil such as the soil shear angle (ϕ), cohesion (c), and unit weight. The settlement can be reduced by increasing the density of the cavity through the compaction of soil particles [2]. Shear failures and resettlement should be considered when designing foundations. To increase the carrying capacity of the soil, two criteria must be met: the stability criterion and the subtraction criterion [3].

Soils with expansive characters are found in clay soils. Soil sediments can be identified based on particle size, plasticity index, liquid boundary and mineral content. AST Mmcn requires more than 50% to pass filter no.200 (0.075 mm) with a minimum plasticity index of 35% [4]. The particle size of

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https://doi.org/10.37934/aram.135.1.117127

mineral content that is commonly found in clay soils with a particle size of less than 0.2 µm is the dominant elements are montmorillonite, beidellite and illtte. Meanwhile, the soil with a particle size greater than 0.2 µm, the dominant mineral elements are kaolinite, micas, illite and felspar.

Natural asphalt found on Buton Island is a mixture of bitumen and minerals. The natural asphalt is formed as a result of geological processes over a long period of time and takes place naturally, caused by petroleum being pushed to the surface, infiltrating between porous rocks. The type of natural asphalt found on Buton Island is rock asphalt found in the Kabungka area and soft asphalt found in the Lawele area (Figure 1). The total natural asphalt deposits on Buton Island are estimated to be no less than around 300 to 600 million tons. The first detailed report on the geology of Buton was compiled by Hetzel in 1936. Asbuton deposits in Kabungka are estimated at 312 million tonnes with an average mineral content of 80%, while asbuton deposits in Lawele are estimated at 99.5 million tonnes with an average mineral content of 78% [5].

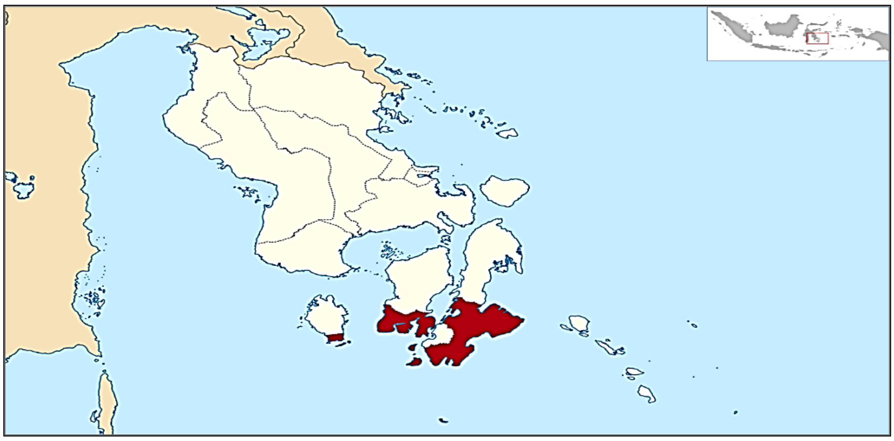


Fig. 1. Map of the spread of Buton asphalt deposits (Source: Geological map of the Buton sheet area)

Asbutone minerals are generally composed of limestone bedrock. Based on the type of mineral, asbuton can be distinguished into two, namely:

i. Minerals from Globugerine lime (fossils of marine animals): shaped like black rocks, in cold air brittle and easily broken and in hot air quite plastic difficult to break.
ii. Minerals from Mergel Lime (lime containing clay): a plastic object that is black and plastic in nature is difficult to mine. Asbutone minerals in general (almost 85%) are composed of limestone bedrock derived from marine animal deposits, very porous and relatively light, while the elements that affect the hardness of asbutone mineral grains are Fe^2O^3, Al^2O^3, SiO^2 [6].

Table 1 show the amount of potential mentioned above, which has been processed since the Netherlands era until now, it is only about ±. 7.5 million metric tons, or about 9.02% of the existing potential. Buton Asphalt is limestone or sandstone impregnated with asphalt [3]. Based on the theory of occurrence, the asphalt deposits that seeped into the previous limestone or sandstone formation were petroleum deposits that appeared to the surface due to tectonics. Asbuton is a natural asphalt found on Buton Island with a very large deposit that can be used as a road material because besides containing bitumen, the mineral also has a fairly high lime content ($CaCO_3$) which is around 70%-80% [7]. Currently, there are several manufacturers who are developing pure asbuton products (mineral content < 1%) which are expected to replace oil asphalt. For this reason, bitumen and asbutone minerals, if not used, will disturb the environment in the future. With the problems mentioned above, it is necessary to study the compressive strength of concrete mixture of granular asphalt buton alkali activator concrete on soft soils [8].

Table 1
Deposit asphalt Buton

No	Block	Deployment area (m^2)	Thickness (m)	Block (ton)
1	Rongi	57.755.000	78	226.165.670
2	Kabungka	181.004.200	78	312.718.460
3	Lawele	130.906.500	78	99.786.080
4	Epe	1.720.000	78	2.011.157
5	Rota	4.530.000	78	19.596.780
6	Madullah	620.000	78	2.682.120
	Totals	376.537.850		662.960.267

(Source: Mining and Energy Office, Buton Regency)

Aggregate or stone, or granular material is a hard, compact granular material. The term aggregate includes cobblestone, broken stone, stone ash, and sand, among others. Aggregates have a very important role in transportation infrastructure, especially in this case on road pavement. The bearing capacity of a road pavement is determined largely by the characteristics of the aggregate used. The selection of the right aggregate and meeting the requirements will be decisive in the success of 19 road construction or maintenance (Hot Paved Mixed Work Manual, Book 1: General instructions). The function of the aggregate in the asphalt mixture is as a frame that provides stability to the mixture if done with the right compaction tools. Aggregate as the main component or framework of the road pavement layer contains 90%-95% aggregate based on weight percentage or 75%-85% aggregate based on volume percentage [9].

The entire pavement specification requires that the aggregate particles must be within a certain size range and for each particle size must be in a certain proportion. The distribution of this variation in aggregate grain size is called aggregate gradation. The aggregate gradation affects the size of the cavity in the mixture and determines the workability (ease of workability) and stability of the mixture. To determine whether the aggregate gradation meets the specification or not, an understanding of how particle size and aggregate gradation are measured is required. The aggregate gradation is determined by a sieve analysis, where the aggregate sample must pass through a set of filters [10].

2. Methodology

The material used in this study is Asbuton from Buton Island, with sampling carried out at the Lawele sampling location. According to Figure 2, it is related to the map and sampling location in the Lawele area.

Fig. 2. Asbutone sampling location

3. Results

3.1 Basic Characteristics/Properties of Sirtu and Asbuton

The materials used in this study consist of two types of materials, namely sirtu material which is used as the basic material of the column and asbuton which is used as a filler as well as a binder. As has been explained, testing material characteristics includes: physical properties (index properties) and mechanical properties [11]. Testing the basic characteristics of sirtu materials includes initial moisture content, specific gravity, sieve analysis, and compaction characteristics [12]. Meanwhile, the basic mechanical test carried out is the California Bearing Ratio. The recapitulation of the results of the basic characteristics test is shown in Table 2.

Table 2 based on examination within the research facility, sirtu materials are overwhelmed by the rock division of 82.48%. With reference to the bound together soil classification framework, the sirtu utilized in this think about is classified as GW, specifically Sandy Rock with great degree, since the CU esteem is 5.16 and CC is 1.29 with little/no fine-grained soil. In the mean time, the mechanical esteem that can be delivered is CBR considering that this type of fabric may be a non-cohesive, granular and free fabric so that it cannot be shaped into a compressive solid example, unless there's a binding fabric [13]. The CBR esteem of 29.08% appears that the sirtu fabric utilized encompasses a decently great execution on the off chance that utilized as a street asphalt establishment layer, to be specific the subbase layer with a least necessity of 20sed on SNI 03-1732-1989 [14].

Table 2
Recapitulation of sirtu characteristics examination results

Test	Test results	
	Value	Unit
Basic properties of gravelly sand :		
Initial water content (w)	3,25	%
Specific gravity (Gs)	2,70	-
Sieve analysis:		
i. Gravel	82,48	%
ii. Sand	15,00	%
iii. Silt and clay	2,52	%
Classification according USCS : GW/GP		
Mechanical properties of gravelly sand:		
California bearing ratio	29.08	%

(Source: Research data 2024)

From Figure 3, based on the USCS classification system, the material used is classified as GW because based on the results of the filter analysis, it shows that the fraction of grains held by filter #4 is more than 50% with a value of CU > 4 and 1 < CC < 3 [15]. Then the fine-grained soil fraction is less than 5%. So, in general, the sirtu used is classified as Clean Gravels because the fraction of fine-grained soil is very small [16]. Figure 4 show the grain gradation of the aggregate presentation with the resulting diameter.

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)		
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	
	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	
	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures

Fig. 3. Soil classification based on USCS

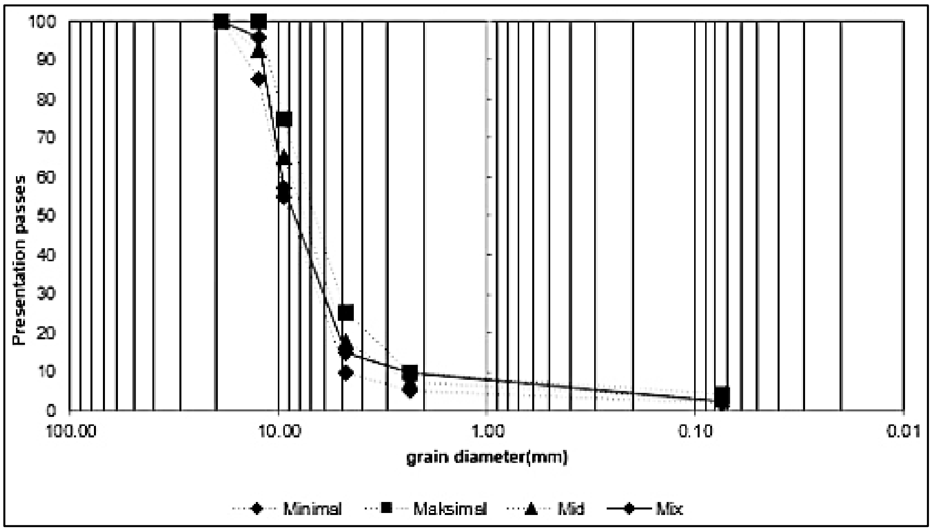


Fig. 4. Grain distribution chart

3.2 Characteristics of Asbuton Microstructure

The composition of chemical elements and the surface description of the microstructure of asbutones are known by SEM-EDS (scanning electron microscopic with energy dispersive spectroscopy) testing, see Figure 5 [1,14]. The comes about of testing the chemical structure of asbutones appear that asbutones are ruled by SO_3 or sulfur compounds.

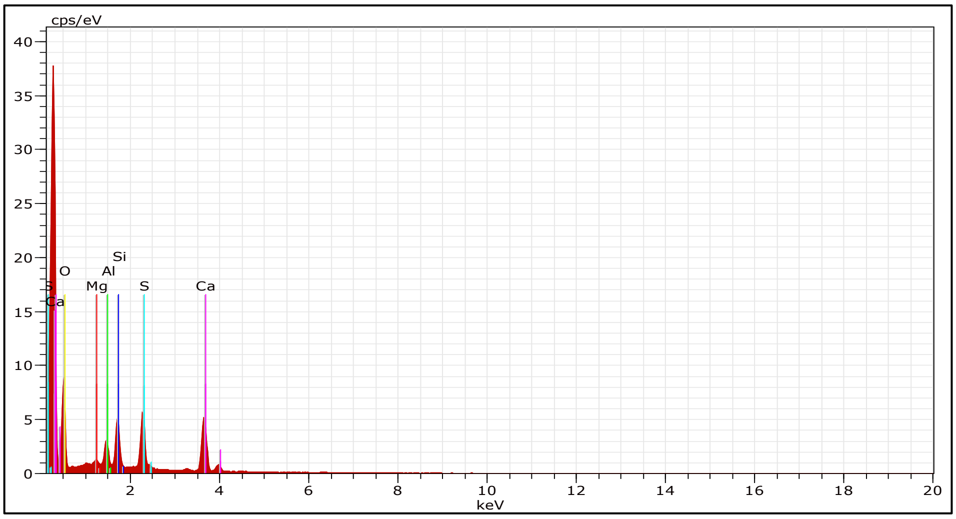


Fig. 5. Asbuton micrograph spectrometry (SEM EDS)

In expansion to Sulfur, asbuton moreover contains a part of CaO or Lime compounds [12]. In expansion to these two compounds which have a rate of more than 50% of the overall components, there are 2 compounds that have a littler rate, to be specific SiO_2 or silica at 19.61% and Al_2-O_3 or aluminum at 12.47%. The compounds slightest display in asbutones are sodium and magnesium [17]. Figure 6 show the chemical results of the characteristics of Buton asphalt.

Spectrum: test

Element	unn. C	norm. C	Atom. C	Compound	norm. Comp. C	Error (3 Sigma)
	[wt.%]	[wt.%]	[at.%]		[wt.%]	[wt.%]
Oxygen	30.67	45.72	62.43		0.00	12.27
Sodium	2.27	3.38	3.21	Na2O	4.56	0.59

Fig. 6. Chemical structure of Asbuton

3.3 Mix Design of the Sirtu Column Elements

Based on the comes about of the channel investigation, the rate of rock to sand was gotten in common was 80:20. So in this ponder, a few varieties of degree will be utilized by changing the proportion between rock and sand in arrange to get the finest interlocking grain degree. Moreover, after the finest degree is gotten, the percentage of sand will be substituted utilizing asbuton as a filler. In deciding the most excellent degree, CBR testing is utilized which alludes to ASTM D-1883 [18]. Before testing CBR with mix variations as shown in Table 3, it is necessary to re-test standard proctor with the mix variation with the aim of determining the optimum dry density and moisture content in each mixture composition [7,9].

Table 3
Mix design sirtu column elements

Mix	Sand (%)	Gravel (%)	Total (%)
S1	20	80	100
S2	15	85	100
S3	10	90	100

Figure 7 The compaction characteristics using the standard proctor method based on ASTM D-698 show that the sirtu used has a maximum dry fill weight of 1.95 gr/cm^3 which can be achieved with an optimum moisture content of 6.01%.

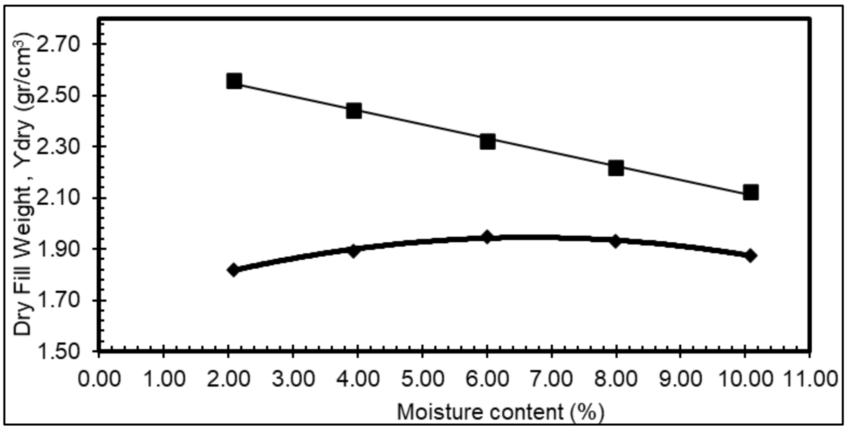


Fig. 7. Relationship between dry fill weight and sirtu moisture content

The results of the physical and mechanical characteristics of the asbuton show that the asbuton is classified as SP/poorly graded sand. The CBR value shows a lower value compared to sirtu. The results of this test are in accordance with the table of Figure 3, which is the poorly graded sand shown in red. The comes about of the physical and mechanical characteristics of the asbuton appear that the asbuton is classified as SP/poorly reviewed sand. The CBR esteem appears a lower esteem compared to sirtu [7]. Table 4 show the recapitulation of asbuton properties.

Table 4
Recapitulation of asbuton properties

Test	Test results	
	Value	Unit
Basic properties of over boulder:		
Specific gravity (Gs)	2.68	-
Sieve analysis and hydrometer:		
Sieve analysis:		
i. Gravel	0.00	%
ii. Sand	85.00	%
iii. Silt and clay	15.00	%
Standard proctor:		
i. Maximum dry density, (γd)	1.28	gr/cm^3
ii. Optimum moisture content (OMC)	25.67	%
Classification according USCS: SP		
Mechanical properties of over boulder		
California bearing ratio	1.798	%

(Source: Research data 2024)

Furthermore, based on Figure 8, graph of asbuton grain distribution, it can be seen that based on the results of the sieve analysis test on asbuton material, the result is that the asbuton material is dominated by a sand fraction of 85% and a fine grain fraction of 15%. So based on the unified soil classification system, asbuton materials based on their gradation are classified as SP, namely sand with more than 12% fine grains [14]. Table 5 is the result of the recapitulation of the proctor standard for the determination of gamma dry, where this gamma dry is the maximum standard of three samples.

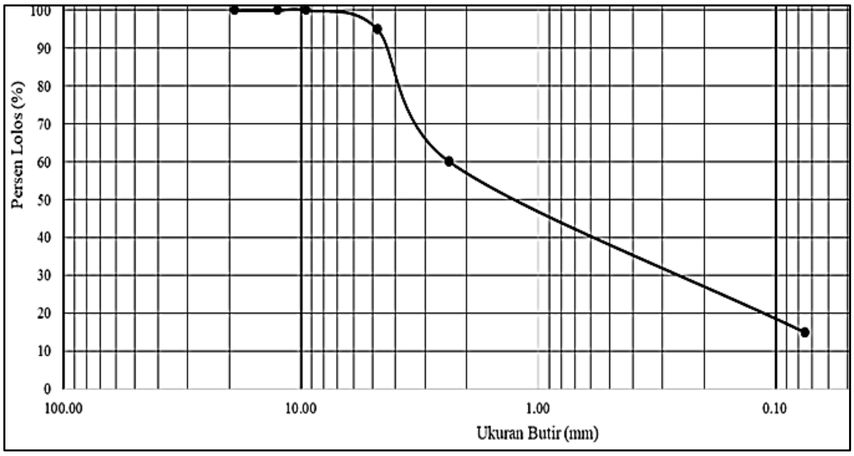


Fig. 8. Asbutone granule distribution chart

Table 5
Recapitulation of standard proctor test results

Mix gradient variations	ɤ Dry max (gr/cm³)	OMC (%)
S1	1.87	6.01
S2	1.89	5.91
S3	1.93	5.68

(Source: Research data 2024)

Based on Figure 9. The compacts test was carried out with the aim of obtaining the values of ɤDry, ɤWet and the optimum moisture content of the sample. ɤDry is the dry fill weight of the sample or dry density, i.e. the weight of a solid material in a volume. Meanwhile, ɤWet is the wet density of the sample, which is the weight of solid material and water at a volume. This variable is used in determining the composition of the mix design specimen to be compacted, and is the basis for calculation in compaction for other test samples. Based on Figure 4 The compaction characteristics using the standard proctor method based on ASTM D-698 show that the asbuton used has a maximum dry fill weight of 1.28 gr/cm^3 which can be achieved with an optimum moisture content of 25.67%.

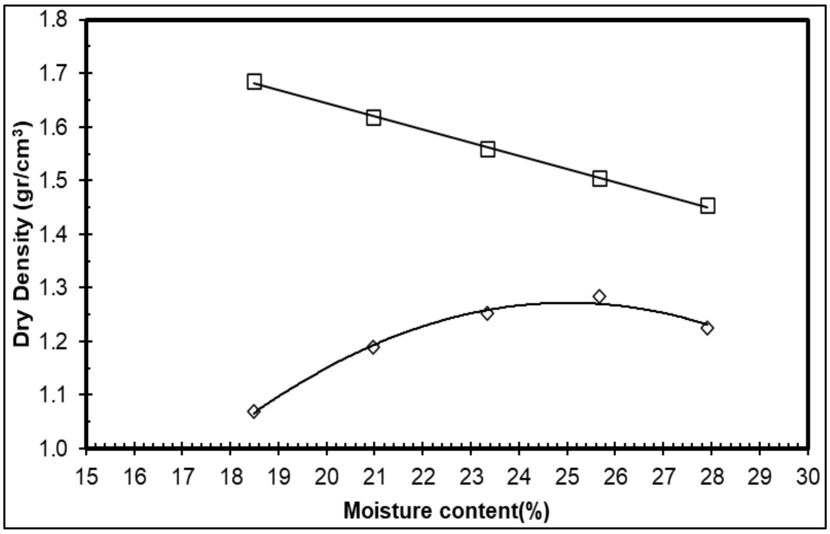


Fig. 9. Relationship between dry fill weight and asbutone moisture content

Based on Figure 10 the comes about of the standard test of the delegate on the degree variety, it appears a cross design between the alter of the ideal dampness substance and the greatest dry fill weight. As the rate of rock to sand to add up to example weight increments, the ideal dampness substance diminishes. This is often since the water retention of rock is littler than sand.

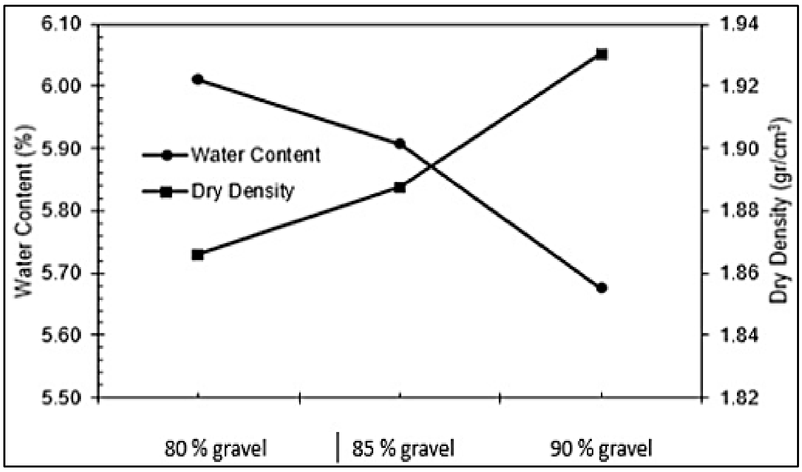


Fig. 10. Effect of gradation on changes in optimum moisture content and maximum dry fill weight

Figures 11 and 12, the comes about of the CBR test on degree varieties appear very a differentiating contrast. Whereas, Table 6 show the CBR value realtive to gradient variation. Composition 3 with 90% rock and 10% sand appears a CBR esteem of 26%. Composition 2 with 85% rock and 15% sand appears a CBR esteem of 29%. Whereas composition 1 with 80% rock and 20% sand appears a CBR esteem of 16%. From these comes about, it can be concluded that the most excellent composition is 85% rock and 15% sand with the most noteworthy CBR esteem of 29% compared to the other two compositions.

It is expected that the interlocking that happens between the grains is superior than the other two compositions. It is expected that the interlocking that happens between the grains is better than the other two compositions. It appears that the more rock is included to a blend, the thickness esteem will increase, whereas the ideal dampness substance esteem will diminish, and the soil CBR esteem will increment together with the increment in soil thickness esteem [18].

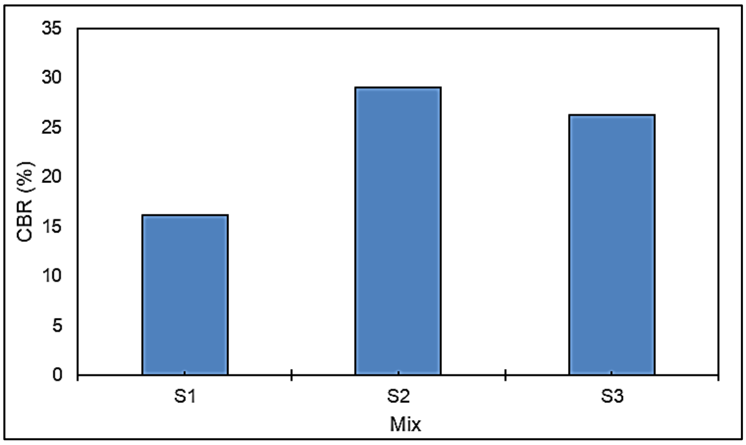
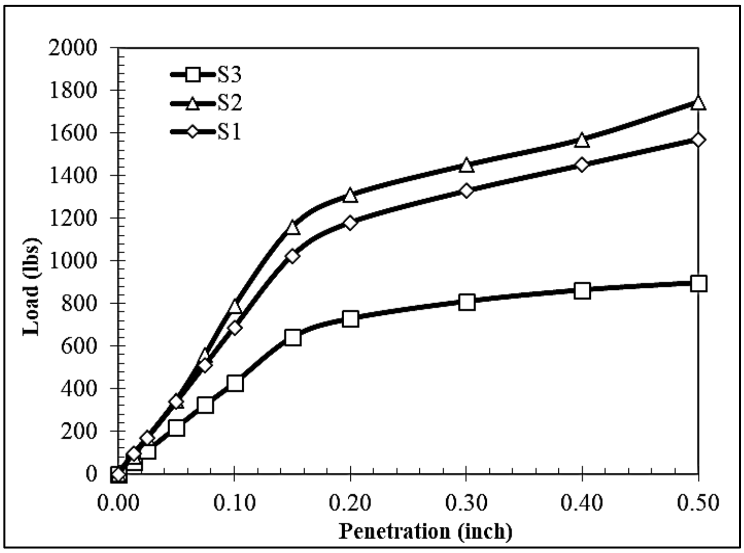


Fig. 11. Recapitulation of gradation variations on CBR values

Table 6
CBR value relative to gradient variation

Sample	Mix.	CBR (%)
S1	80% gravel and 20% sand	16
S2	85% gravel and 15 % sand	29
S3	90% gravel and 10 % sand	26



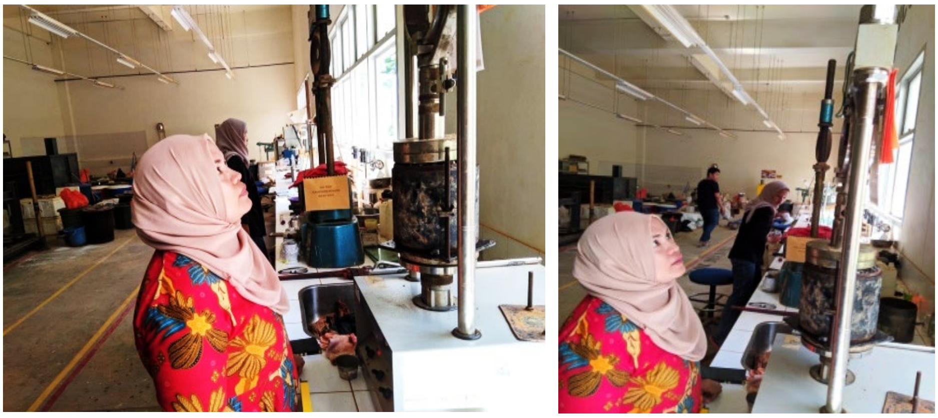


Fig. 12. Documentation of CBR test gravel and sand

4. Conclusions

The comes about of the physical and mechanical characteristics test appeared that the sirtu was classified as Sandy Rock with little/no fine-grained soil and Asbuton was classified as a ineffectively evaluated classification/SP based on USCS. In the interim, the comes about of the microstructure test appear that Asbuton is ruled by SO_3 or Sulfur compounds and contains lime and silica that can tie to other materials.

Subsequently, where the comes about of the cbr for the 3 compositions deliver diverse comes about where the interlocking that happens between the grains is superior than the other two compositions. In conjunction with a ponder conducted by Kurniadi [18] entitled “The impact of rate of smashed shake substance on the CBR esteem of a sandy soil”, it appears that the more rock is included to a blend, the thickness esteem will increment, whereas the ideal dampness substance value will diminish, and the soil CBR esteem will increment beside the increment in soil thickness esteem.

Acknowledgement
This research was supported by Universitas Muslim Indonesia, Tadulako University and Dayanu Ikhsanuddin University.

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