Buton Natural Rock Asphalt (BNRA) Modified Base Course Material

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Abstract-In flexible pavement, base course is the layer immediately under the wearing surface layer. Because the base course lies close under the pavement surface, it is subject to severe loading. It follows the materials in a base course must be of extremely high quality. To get high quality of base course, research on treated base course with Buton Natural Rock Asphalt (BNRA) have been conducted. Amount of 10, 15, 20, 25, 30, and 35% BNRA by weight of base course aggregate are mixed in the base course aggregate. California Bearing Rasio (CBR) and direct shear test are performed to the mixed of BNRA-base course and also to the original base course to konw how far the influence of BNRA to improve the strength or quality of the base course. The test results show that with BNRA 25% the CBR value can increase from 52.30% to 98%, and cohesion change from 0.127 for original become 0.199 for base course treated BNRA, as well as angle of internal friction (φ) increase from 21^0 to 43^0. It can be concluded that BNRA is suitable to use as material for treated base.

Keywords: *Buton-Natural Rock Asphalt, Treated, Base Course, Improve, Strength.*

1. Introduction

1.1 Background

From the beginning of mankind, transport, especially road transport has become a major aspect of human life. Communication and commerce would not be possible without it. To this end, thousands of kilometers of roads have been built all over the world. Indonesia, a country with a land area of 1.922.570 square kilometers and a population of 258 million people (2016 estimate), based on the authority level, Indonesia has 523 974 km long road which consists of 47 017 km of State roads, provincial roads and 55 416 km 421 541 km of road district / city.

Started from the pavements built on Crete during the Minoian period (2600 – 1150 B.C.) mankind continuously develop the construction of road. The famous ancient road construction was built by the Romans. It should be noted that these pavements were remarkably well designed. From those early days of the Roman Empire to the interstate highway system in the United States, roadway networks as well as roadway construction have been developed. The materials used for roadway construction have progressed with time.

In the development, pavements can be broadly classified into two types, flexible and rigid pavement. From the two types of roadway pavement, flexible pavement is the most used in the world at the moment. In Indonesia, for instance, from 91,620 kms length of road, 508,620 km or 95.64% are flexible pavement roads, and roads constructed with rigid pavement are only 343 kms or 0.37%, while the rest of 3.99% are earth/gravel roads. In the United States as of 2001 there were about 2.5 million miles of paved roads of which 94% were bituminous surfaced. Figure 1.1 shows basic flexible pavement structure

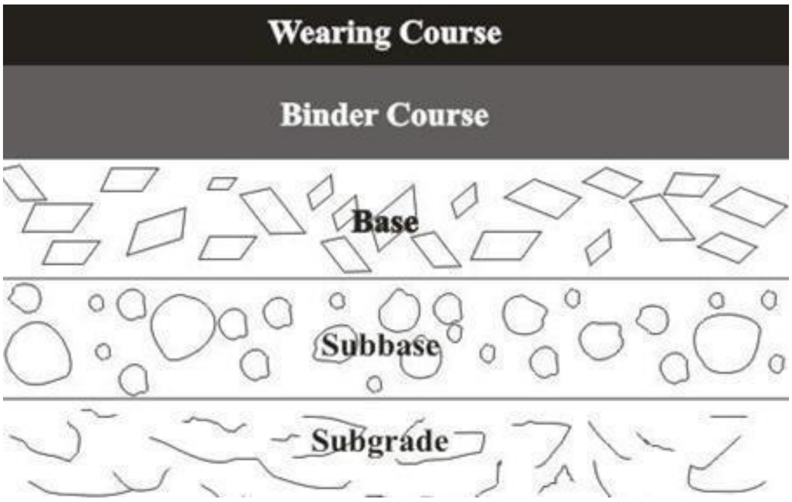

Figure 1. Basic flexible pavement structure

In most asphalt pavement, stiffness of each layer or lift is greater than in the lower layers and less than that in the upper layer. It can be understood from the distribution of the load (Figure 2) in which the stress in the surface layer is higher than the bottom layer.

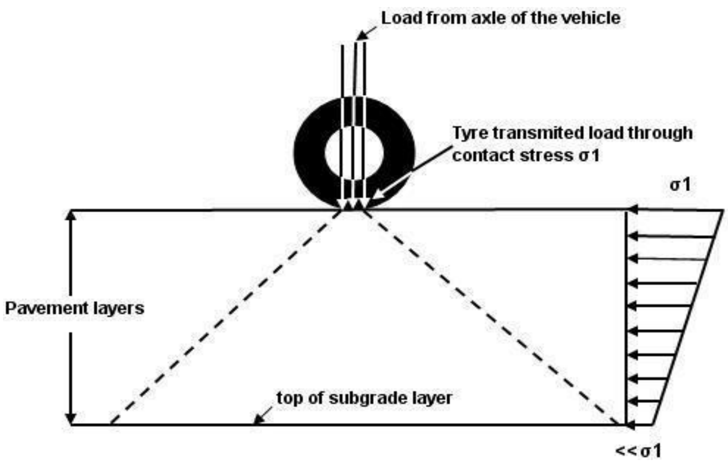

Figure 2. Load distribution on flexible pavements

Base course layer is the layer directly placed under the surface layer. Since the surface layer relatively thin, the tire load that have to be supported by base course layer stilll significantly high. Therefore, to be able support the traffic load and also the surface layer, base course layer have to have enough strength and also a high stiffness as well. To fulfill those strength and stiffness base course layer should be made from the good material.

1.2 The Objectives of the Research

From the description above it is clear that the material of base course layer should be treated to improve it strength and stiffness. Therefore, this study has the following objectives:

a. To investigate the feasibility of using Buton Natural Rock Asphalt (BNRA) to improve the strength of base course material.
b. To look for the strength parameter of base course after treating with BNRA.
c. To evaluate the levels of use BNRA on flexible pavement.

2. Testing Program

2.1 Base Course Material

Base course layer is the layer immediately under wearing surface (Figure 1). This definition applies wether the wearing surface it bituminious or cement concrete 8 or more inches thick or is but a thin bituminous surface treatmen. Because the base course lies close under the pavement surface, it is subject to severe loading. It follows that materials in a base course must be of etremely high quality and constraction must be carefully done [3]. In general the base course has the following functions:

1. Pavement with stand the horisontal force of wheel load and pass it to the layer below.
2. Permeation layer to the bottom base layer.
3. Bearing against the surface layer.

As mentioned before that the materials used for base course must strong enough, namely have CBR value above 50%. Base materials such as crushed stone, gravel, can be used as material base course.

Gradation of base course material must be well graded, and based on the gradation base course devided into 3 classes, class A, B, and class C. Maximum particles size of class A higher than class B, and class B higher than class C. Spesification of each class can be seen in Table 1.

Table 1. Base Course Gradation [4]

SIEVE DESIGN	CLASS A	CLASS B	CLASS C
4	100		
2	85-100	100	
1-1/2			
1			100
3/4			
3/8			
No. 4	30-70	30-70	40-75
No. 8			
No. 10			25-55
No. 40			
No. 200	0-10	3-10	4-10

2.2 Aggregat

Aggregate is a mineral particles in the form of granules which is one use in combination with various types, ranging from as materials in cement to form concrete, base course,material aggregate, filler, etc [5]. Aggregates are generally defined as the formation of the earth Kulis hard and dense. ASTM defines aggregate as a material that consists of solid material, in the form of mass large or in the form of fragments. Aggregate is the main component of road pavement structure is 90-95% of aggregate based on the percentage by weight or 75-85% aggregate based on a percentage volume. Thus the quality of the pavement is determined by the nature and aggregate mix with other materials.

Selection agragegat used must consider the availability of materials at the location, type of construction, grading, maximum size, cleanliness, durability, shape, texture, stickiness of the aggregate of the asphalt, and its density.

2.3 Buton Natural Rock Asphalt (BNRA)

Buton Natural Rock Asphalt (BNRA) is the natural asphalt which found in Buton island in South-East of Sulawesi main island. The areas in Buton island which contain much rock asphalt is Lawele, Kabungka, Waisiu, Wariti, and Epe. From those five areas, Lawele and Kabungka have much deposit of rock asphalt.

BNRA was found firstly in the year 1926 by Hetzel, a Dutch Geologist. Estimate the deposit of rock asphalt which can be measured is 650 million ton from an amount two billion ton based on the result of survey conducted by Ministry of Energy and Mineral Resources Republic of Indonesia. Bitumen content consist in the rock asphalt varis between 20 to 30%. Deposit of BNRA can be found only in the depth of 1 to 1.5 meter from the land surface.

From the beginning explore up today, volume BNRA which have been explored was only 3.4 million ton. The gradation and properties of BNRA was given in Table 2.

Table 2. Gradation and Properties of Buton-NRA

NO.	TEST	TEST METHOD	RESULTS	SPECIFICATION	UNIT
1	Gradation	ASTM C 136			
	Sieve no. 16		100		% passing
	Sieve no. 30		54.02		% passing
	Sieve no. 50		16.97		% passing
	Sieve no. 100		3.75		% passing
	Sieve no. 200		1.82		% passinh
2	Bitumen content	ASTM D1856	22.52	18 - 22	%
3	Solubility in C_2HCL_3	ASTM D2042	18.72	Minimum 18	%
4	Specific Gravity	ASTM D854	1.976	1.70 – 1.90	-
5	Flash Point	ASTM D9272	232	Minimum 230	°C
6	Water Content	ASTM D1461	0.81	Maximum 1	%
7	Volatile Content by Distillation	ASTM D402	0.20	-	%

Source: Buton Asphalt Indonesia

2.4 Sieve Analysis Test

This experiment was carried out with a view to determining the gradation of aggregate base samples. The experimental procedure were : first, Take a sample of dried sufficiently (aggreagte samples) and weighed, eg: A gram. Place the sample in a large cup, given water and then soaked for ± 24 hours. Then washed in a sieve with a diameter of 0,074 mm (no, 200) and the mud was placed alone. The samples were clean of mud oven was then weighed, for example: B gram. Prepare a filter arrangement in vibrator, with more downward Ø vanishingly small. Samples are already weighed is placed on the top sieve, then vibrated ± 15 minutes. Each sample retained on the filter is placed in aluminum, and then weighed.

2.5 Compaction test (Modified proktor)

The purpose of them to tamp aggregate compaction in a state level optimum moisture, so the air inside the pores of the aggregate will be out. To know the optimum moisture content in the aggregate, compaction testing performed modified proktor. The water content that provides maximum dry weight is called the optimum water content. Create a curve of the relationship between water content (w) as abscissa and the weight of dry aggregat volume as ordinate, the peak of the curve as the value (γd max), the curves used are curves of aggregate compaction tests (Proctor standard). From the cusp of a vertical line drawn cut abscissa, at this point is the water content optimum.

2.6 Direct shear test

This experiment aims to obtain the amount of shearing resistance on normal stress certain aggregate. The goal is to obtain the shear strength.

2.7 Calivornia Bearing Coarse (CBR) test

This examination is intended to determine the price of aggregate base CBR compacted in the laboratory at a certain moisture content. In addition, this inspection also intended to determine the relationship between water content and density Aggregate. Test CBR Laboratories refers to the AASHTO T-193-74 andASTM-1883-73. For the planning of new roads, pavement thickness is usually determined from the value of CBR of the compacted subgrade. CBR value is used for this plan is called "design CBR".Methods used to get a "design CBR" is determined by calculation of two factors, namely:

a. The water content of the aggregate as well as dry bulk density when compacted.

b. Changes in the water levels are likely to occur after the pavemen tcompleted.

The CBR number (or simply CBR) is obtained as the ratio of the unit load (in pounds per square inch) required to effect a certain depth of penetration of the penetration piston (with an area of 3 sq in) into a compacted specimen of soil as some water content and density to the *standard unit load* required to obtain the same depth of penetration on a standard sample of crushed stone. In equation from this is.

$$\text{CBR} = \frac{testunitload}{standardunitload}\ 100\ \% \qquad \text{Eq. 2.1}$$

From this equation it can be seen that the CBR number is a percentage of the standard unit load. In practice the percentage symbol is dropped and the ratio is simply noted as a number such as 3, 45, 98. Values of standard unit load to use in Table 2.3 are as follows:

Table 3. Values of standard unit load

Penetration (in)	Standard unit load (psi)
0.10	1.000
0.20	1.500
0.30	1.900
0.40	2.300
0.50	2.600

3. Test Result and Discussion

3.1 Summary Tests of Original Base

Table 4 shown the summary result tests of original base is called characterization of original base.

Table 4. Characterization of Base Original

Physical Parameter	Value
Property Index	
1. Specific Grafity	2,702
Soil Tests (modifie compaction)	
1. Optimum Water Content (%)	9.4
2. Dry Maximum content	2.04
CBR design	
Unsoaked	52.3
Direct Shear Tests	
1. Cohesion (c)	0.127
2. Angle of internal friction φ (°)	21

3.2 Statistically Analysis BNRA Treated Base

In this study, Buton Natural Rock Asphalt (BNRA) serves as additional material that is used to improve the quality of the base layer course. In the research phase of this time, there are differences in the stage of getting value direct comparison of quality of test and CBR. If the test base without BNRA, should get value optimum levels to get the highest density of aggregate value. In Buton Natural Rock Asphlat (BNRA) treated base, starting with the mixing of oil in BNRA with the purpose to enable aggregate asphalt as a base course reinforcement layer. All of the test results will be statistically analysed using student t distribution (Figure 3) and simple regression model.

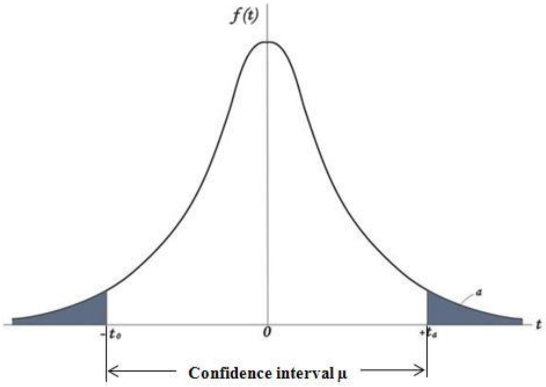

Figure 3. Student t distribution

3.3 Direct Shear Test

The result of direct shear test results are shown in Table 6 Statistical analysis using student t distribution (Figure 3) Statistical analysis for direct shear tests using Student t distribution is given in Table 5., and regression model shown in Figure 3.2.

Table 5. Results of Direct Shear

Variable Mix	c	φ (°)
10%	0.199	21
15%	0.124	37
20%	0.068	43
25%	0.0191	22

Variable Mix	c	φ (°)
30%	0.079	42
35%	0.005	36

Table 6. Statistical Analysis o Direct Shear Test of BNRA-Soil Mixtures

Mean of CBR	Standard Deviation (σ)	Coefficient of Confident (%)	Confidence Interval (μ)	Coefficient of Correlation R	Coefficient of Determination R-square
33,50	-2,5000	95	12 < μ < 55	0,381	0,1449

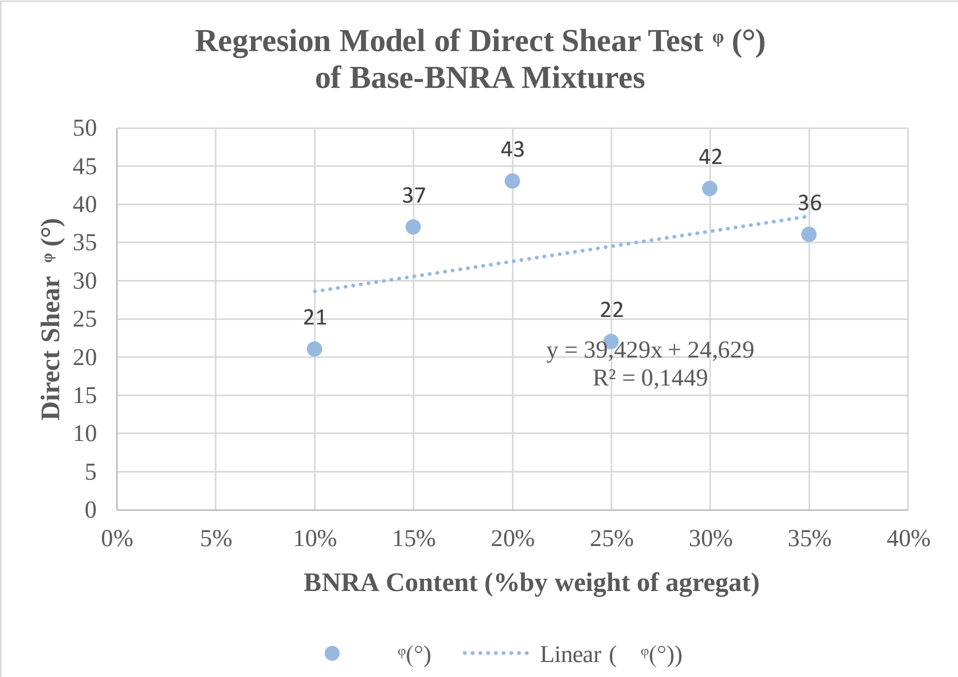

Figure 4. Regression models Direct Shear φ of stabilizing aggregate with BNRA

Test data have confidence coefficient of 95% and a confidence level of 12 <μ <55 had a 95% confidence level for all BNRA-Aggregate base. Meanwhile, coefficient of determination R^2 = 0.1449 and coefficient of corelation R=0,318, indicating that the direct shear is not so significant figure of BNRA treated base.

3.4 California Bearing Ratio (CBR) Test

CBR value shown in Table 3.5. Statistical Analysis for CBR value using student distribution given in Table 3.4., and regression model shown in Figure 3.3. Test data have confidence coefficient of 95% and a confidence interval of 31<μ<111 had a 95% confidence level for all BNRA-Base. Meanwhile, coefficient of determinantion R^2 = 0.9074 and coefficient corelation R = 0,999, show that CBR value is very significant figure of BNRA-Base mixtures.

Table 7 Results CBR Value

VariableMix	CBR(%)
0%	52.3
10%	60.97

VariableMix	CBR(%)
15%	78.08
20%	91.066
25%	98.733
30%	63.92
35%	43.27

Table 8. Statistical analysis of CBR test of BNRA-Base

Mean of CBR	**Standard Deviation (σ)**	**Coefficient of Confident (%)**	**Confidence Interval (μ)**	**Coefficient of Correlation R**	**Coefficient of Determination R-square**
71,20	27,9317	95	31 < μ < 111	0,953	0,9074

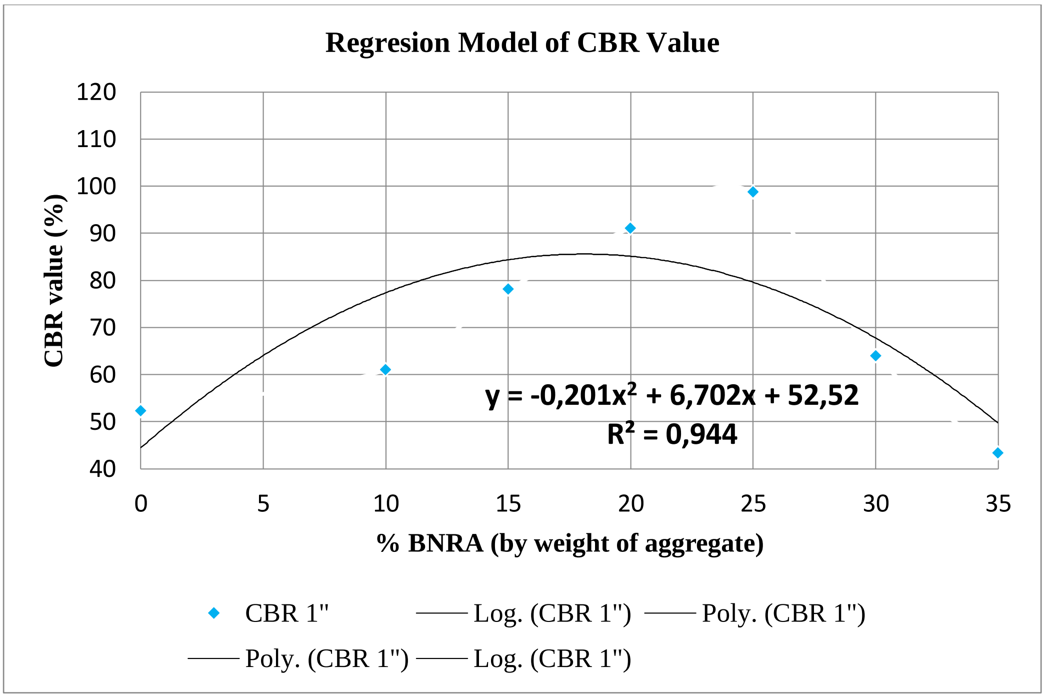

Figure 5. Regresion of the value of CBR

4. Conclusions

From the results obtained in this study, the following two conclusions can be drawn as follows:

1) Buton Natural Rock Asphalt (BNRA) significantly can be used to treated base to improved the strength of base course material.
2) That statement is proved by increasing of CBR unsoaked values, where CBR increase from 52,30 % of original base course to 78 %, 91%, 98,72%, and 63,92% after added with BNRA 15%, 20%, 25%, and 30% treated base respectively. BNRA also have improved the stiffness of base course material, which is proved by cohesion and angle of frition values, where cohesion change

from 0.127 for original become 0.199 for BNRA treated base course, as well as angle of internal friction (φ) increase from 21^0 to 43^0.

3) It can be concluded that BNRA is suitable to use as material for treated base.

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