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## Preliminary Study on Compressive Strength of Porous Asphalt Containing Modified Buton Asphalt, Waste Plastic and Limestone Powder

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## Preliminary Study on Compressive Strength of Porous Asphalt Containing Modified Buton Asphalt, Waste Plastic and Limestone Powder

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**Abstract.** Porous asphalt is a surface layer or a wear layer is one of the asphalt material developed to overcome the problem of inundation during the rainy season making it suitable for use in Indonesia which has high rainfall intensity. Furthermore, it is necessary to optimize the use of a number of natural resources in Indonesia such as natural rock asphalt in Buton Island (BRA) and limestone which is available in many places. In addition, reducing of plastic waste is attracts the attention of a number of countries including Indonesia. This paper is part of a series of investigate study related to the behaviour of porous asphalt mixture made with modified Buton asphalt (MBA), waste plastic and lime stone powder. The compaction results showed good adhesion can unite the waste Polyethylene terephthalate (PET), limestone powder and coarse aggregate particles. There is no visible negative effect of waste PET and limestone powder in porous asphalt mixture against compressive strength.

### 1. Introduction

Indonesia has high rainfall intensity. Often when it rains heavily, the rain floods the road a few moments before it flows into the drainage drain. Inundation that occurs on the road body causes several problems for motorists. Some of these include splashing water that causes view obstructions and reduced tire grip on the road causing easy slip. Porous asphalt is a surface layer or a wear layer is one of the asphalt material developed to overcome the problem of inundation during the rainy season. In contrast to the dense asphalt mixture which has a micro porosity of about 4-6%, porous asphalt mixture is formed by most of the coarse aggregates bound by bitumen, where fine aggregate or filler is added in small amounts. Because the mixture is made using mostly coarse aggregates with small amount of filler or fine aggregates, coarse aggregate skeletons can be formed and bond with bitumen where interconnected porosity with diameters of about 5 mm occurred. Porosity volume is around 10-25%. Interconnected porosities have a function to flow water from the upper part of the surface layer through the porous asphalt body to the waterproof layer below. Thus the water will be reduced quickly, thereby reducing inundation on the surface. Coarse aggregates well arranged on porous asphalt will increase the friction between the tire and the road surface so that the vehicle does not slip easily [1-3].



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Many places in Indonesia are covered by limestone hills and mountains. As a result of the weather and temperature that often changes, the upper parts of some layers of limestone are easily peeled off due to scouring and erosion to form powder that pass sieve no.4 to sieve no.200. This study used limestone powder that have been eroded and peeled from the top part of the limestone layer. The limestone powder was grinded and filtered through the No. 200 sieve to obtain limestone powder which was used as filler in this study.

Nowadays the use of plastics including PET plastic continues to increase. PET plastic is widely used, one of which is as an ingredient for making soft drink plastic bottles. This resulting in the amount of plastic including PET plastic that is not used and becomes waste continues to increase. Plastic materials that are wasted are not easily decomposed and remain in their intact form for a long time in nature, causing many problems to the environment.

On the other hand, the nature of plastics including PET plastic that is not easily biodegradable shows the nature of its good resistance to environmental influences. Good resistance of waste PET is expected to have a positive effect when PET waste is used with other materials. Based on existing research literatures, PET in natural state is semi-crystalline resins [4-6], and has a glass transition temperature ( $T_g$ ) around 70°C [7-9].

One positive effort to overcome the problem of waste plastic is to use it as a construction material. In recent years there have been several studies using waste PET as an added material in the manufacture of asphalt concrete mixtures. The use of waste PET as added material produced concrete asphalt mixtures which have better physical properties. This is caused when heating waste PET that has been softened turned into a material with properties of crystalline and semi-crystalline so that when mixed with bitumen causes the dense asphalt concrete mix is stiffer with better physical properties than dense asphalt concrete mix without waste PET [10, 11].

Natural rock asphalt is formed from hydrocarbon material that has been strongly integrated with sediment deposits. In some areas in southern Buton, Buton Island, Indonesia are covered with natural rock asphalt deposits. The content of Buton Rock Asphalt (BRA) is about 30% bitumen and 70% mineral, most of the bitumen characteristics of BRA resemble petroleum bitumen characteristics. In recent decades these natural asphalt rocks have been successfully processed into several forms. Concrete asphalt mixtures with physical characteristics that meet the requirements for concrete asphalt mixtures can be achieved by using BRA products as a partial replacement for petroleum bitumen [12, 13].

In recent years, a number of natural rock asphalt processing plants have succeeded in refining the bitumen content so that it is separated from minerals. Bitumen distilled from natural rock asphalt is mixed with petroleum bitumen to produce modified Buton asphalt (MBA). The use of the MBA is expected to further reduce dependence on petroleum bitumen as a binding material in making asphalt concrete mixtures.

The research presented is one part of a series of effort to increase the use of processed Buton natural asphalt products. This research is an initial attempt to provide an overview of the use of MBA, waste PET and limestone powder to make the basic design of a mixture of porous asphalt. Compressive strength is a test of physical characteristics used to assess the preliminary mixture of porous asphalt containing MBA, PET waste and limestone powder.

Figure 1 shows a surface layer including a layer made with porous asphalt when receiving vehicle loads. At the top part of each layer, compressive stress will arise and at the bottom part, tensile stress will occur. Therefore, it is deemed necessary to assess the ability of a surface layer including the porous asphalt layer to accept loads that will cause compressive stress.



**Figure 1.** Surface layer including a layer made with porous asphalt when receiving vehicle loads

## 2. Material and Procedures

### 2.1. Modified Buton Asphalt (MBA)

This study uses an MBA produced by a national company that processes rock asphalt. The MBA used in this study can be widely obtained in the market. Table 1 shows the physical properties of the MBA. Most of the physical properties of the MBA meet the requirements of the bitumen used to make concrete asphalt mixtures.

**Table 1.** Physical properties of Modified Buton Asphalt (MBA)

No	Properties	Value	Unit
1	Penetration at 25°C	78.6	0.1 mm
2	Softening Point	52.0	°C
3	Ductility	114.0	cm
4	Flash Point	280	°C
5	Density	1.12	
6	Loss on Heating TFOT	0.3	% wt
7	Penetration after loss on heating	86	%
8	Viscosity 135 Cst (Temp. mixing)	1826	°C

**Table 2.** Physical properties of coarse aggregate and filler

No.	Properties	Crushed stone	Limestone powder filler
1	Specific gravity		
	a. Bulk/dry	2.62	2.55
	b. Surface saturated dry	2.68	2.61
2	Apparent	2.77	2.71
	Abrasion (%)	25.72	-
3	Unit weight (kg/m <sup>3</sup> )		
	a. Loss	1.30	1.08
	b. Compact	1.49	1.32
4	Flakiness (%)	10.23	-
5	Sand equivalent (%)	-	85.71
6	Absorption (%)	2.07	2.35

2.2. Coarse Aggregate and Filler

River stone that have been processed into crushed stone was used as coarse aggregate in this study. The largest size of coarse aggregate passed the 20 mm sieve. The water absorption, particle size distribution, dens<sup>6</sup> and fineness modulus of the aggregates met the specification of of material for road pavement. The physical properties of the coarse aggregate and filler are given in Table 2.

3. Sample Preparation

According to the selected materials characteristics, the optimum MBA was 6.0% of the total aggregate weight. Specimens of porous asphalt mixtures were prepared using different ratios of waste PET (0–1.5%) and lime powder filler content was observed to be 10% of the total aggregate weight. The mixtures matrix is shown in Table 3. Impact compaction of Marshall Hammer was applied with 50 blows to each face of the specimens. Porous asphalt mixture was prepared in amount to produce specimen weighting 1,600 g. The specimens were mixed and compacted at temperature of 135–140°C.

Table 3. Porous asphalt mixture composition (1,600 grams)

No	Description	Unit	Weight in the mixture			
1	Waste plastic PET	%	0	0.5	1.0	1.5
2	weight	gr	0	7.52	15.04	22.56
3	MBA weight	gr	96.00	96.00	96.00	96.0
Number of sieve						
4	3/4"	gr	0.00	0.00	0.00	0.00
5	1/2"	gr	38.27	37.02	35.76	34.51
6	3/8"	gr	638.60	657.35	636.09	634.84
7	No. 4	gr	601.53	600.28	599.02	597.77
8	No. 8	gr	75.20	73.95	72.69	71.44
9	No. 200	gr	98.21	96.96	95.70	94.45
10	Pan (Lime)	gr	52.19	50.94	49.68	48.43
11	Total aggregate weight (4+5+6+7+8+9+10)	gr	1504.00	1504	1504	1504
12	Test object weight (3+11)	gr	1,600.00	1,600.00	1,600.00	1,600.00



Figure 2. Equipment of compressive strength test

#### 2.4. Compressive Strength Test

Figure 2 shows the compressive strength test. Axial strain was derived from two linear variable differential transducers (LVDTs). Compressive strength was conducted according to SNI 03-6758-2002 [14].

### 3. Result and Discussion

#### 3.1. Visual Observations

Visual observations at the time of mixing showed that waste PET that has reached the softening point can be fused with limestone powder and MAB. No accumulation of the softened waste PET or limestone powder at one point. Homogeneous mixing of materials (coarse aggregates, limestone powder, waste PET and MAB) results coarse aggregates well covered by MAB. Likewise, the results of visual inspection on the test specimens that have been compacted, no visible buildup of PET waste that has been softening or limestone powder coagulation in one place. The compaction results showed good adhesion can unite the waste PET, limestone powder and coarse aggregate particles. Connected porosities were formed firmly from coarse aggregate particles which are well covered by MAB, PET waste and limestone powder.

#### 3.2. Compressive Strength and Peak Strain

The compressive strength test results are shown in Table 4. The compressive strength of porous asphalt specimens that did not contain waste PET was 0.83 N/mm<sup>2</sup>, while specimens containing waste PET of 0.5%, 1.0% and 1.5% were 1.05, 1.19, and 1.28 N/mm<sup>2</sup>, respectively. The magnitude of the increase in compressive strength of specimens containing PET waste by 0.5%, 1.0% and 1.5% was 26.50, 43.37, and 54.21%, respectively, compared to specimens without waste PET. Compressive strength increased as the percentage of waste PET added rose.

The peak strain at peak compressive stress are shown in Table 5. The peak strain that correlated with compressive strength of porous asphalt specimens without waste PET was 0.06 mm/mm, while specimens containing waste PET of 0.5%, 1.0% and 1.5% were 0.04, 0.05, and 0.04 mm/mm, respectively. Referring to Table 4, it can be noted that waste PET did not have a significant effect on peak strain of the porous asphalt mixture prepared with MBA.

**Table 4.** Compressive strength test results

Waste PET content (%)	Compressive strength (N/mm <sup>2</sup> )	Increment (%)
0	0.83	100
0.5	1.05	26.50
1.0	1.19	43.37
1.5	1.28	54.21

**Table 5.** Peak strain

Waste PET content (%)	Peak strain (mm/mm)
0	0.06
0.5	0.04
1.0	0.05
1.5	0.04

#### 4. Concluding Remarks

The research described in this paper has four basic objectives, namely developing the use of MAB which is a derivative of BRA, reducing waste plastic by utilizing waste PET as an additive, strengthening the use of limestone powder which is widely available in Indonesia. All of the mentioned materials can be used to make porous asphalt mixture that had the adequate ability to bear the compressive load.

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