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EXPERIMENTS USING ABS PLASTIC SEEDS (ACRYLONITRILE BUTADIENE STYRENE) AS ADDITIONAL MATERIALS IN PORUS ASPHALT MIXTURE

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ABSTRACT

Increasing the strength of the porous asphalt mixture in the field of road contraction, in this context, porous asphalt is often used as road pavement. ABS plastic pellets (Acrylonitrile Butadiene Styrene) have the same properties as asphalt, namely, thermoplastic has a penetration value equivalent to asphalt pen 60/70, plays an important role in road pavement adhesives as an alternative has high strength, and is resistant to deformation itself. The objective of the experiment was to determine the characteristics of Marshall on optimum asphalt content (KAO) and the effect of adding ABS plastic pellets on the performance of porous asphalt was reviewed based on the Marshall test, Cantabro Loss and Asphalt Flow Down. The research used experimental testing methods in the laboratory. The research was conducted with asphalt pen content of 60/70, namely 4%, 4.5%, 5%, 5.5% 6%, and additional levels of ABS plastic pellets 0%, 2%, 4%, 6%, and 8%. From the planned grade for the addition of ABS plastic pellets mentioned above, the optimum bitumen content is obtained, namely 6% with a VIM value at 6% content of 23.61%, for a VMA value of 27.20%, for a stability value of 924.95 kg and the flow value obtained was 3.23 mm. In contrast, the MQ value was 311.15 kg/mm with standard or parameters namely AAPA 2004(Australian Asphalt Pavement Association).

Keywords*:* *ABS; Marshall; KAO; Cantabro Loss; Asphalt Flow Down; Porus Asphalt.*

1. Introduction

Amount Indonesia's population of 264 million people, Indonesia is the fourth most populous country in the world. The large population affects the amount of waste. As the population increases, the amount of waste also increases. Industrial and technological developments can also have negative impacts, such as increasing the amount, type, and nature of increasingly diverse waste Egsaugm, (2019). According to the Central Statistics Agency (BPS), plastic waste in Indonesia reaches 64 million tons per year. Of this amount, 3.2 million tonnes of plastic waste ends up in the oceans. On the other hand, up to 10 billion or up to 85,000 tons of plastic bags are released into the environment annually, and in Indonesia, it generates up to 175,000 tons of waste per day [1].

*Seeds*ABS plastic (*Acrylonitrile Butadiene Styrene*) is commonly used as a packaging material for manufacturing automotive components, electronics, pipes, fittings, hoses, sporting goods, and some household goods. Researchers used ABS plastic pellets (*Acrylonitrile Butadiene Styrene*) as an additive in porous asphalt mixtures to increase stability values higher than conventional asphalt. Measures use existing plastic pellets to reduce environmental problems caused by increasing plastic waste every year, and in Indonesia, it generates up to 175,000 tonnes of waste per day [2].

Acrylonitrile butadiene styrene (ABS) belongs to the group of engineering thermoplastics containing three constituent monomers. Acrylonitrile is chemically stable and heat resistant.

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Butadiene increases impact strength and toughness. Styrene, on the other hand, is rigid and easy to process. There are also different grades of ABS with properties ranging from high to low gloss and high to low impact resistance. Various other properties can also be obtained by adding additives to obtain ABS grades with fire resistance, transparency, high heat resistance and resistance to UV rays [3].

Based on Arlia's research (2018) [4] that hollow asphalt has low stability but high permeability due to the many cavities in the mixture, so other materials need to be added to increase the stability of the mixture. In the research conducted, the addition of plastic to road asphalt can cause gondorukem as a mixture of porous asphalt pavement to increase the strength value of the road due to excessive vehicle loads.

Besides that, there are also other factors such as weather and standing water, with the development of porous asphalt technology, it has a mixture of hot asphalt with Open gradation hereby utilising waste as an additive to porous asphalt. Porous asphalt is an asphalt mixture dominated by coarse aggregate and low sand content to obtain a high porosity value, designed to have a porosity value of more than 20%. High-porosity asphalt mixtures have better characteristics than conventional asphalt mixtures. usually, the durability is not high enough, this can be overcome by using polymer or fibre additives [5]. Porous asphalt or porous asphalt is a new pavement method currently being developed in the world of highway construction. Porous asphalt is an asphalt mixture that uses an open gradation with a coarse aggregate fraction ranging from 70-85% and fine aggregate ranging from 15-30% of the total weight of the mixture [6].

Porous asphalt has several advantages, including reducing surface water loads, reducing noise levels generated by vehicles, and not being dangerous for road users because porous asphalt has a high level of roughness *(skid resistance),* so that the wheels do not slip easily when driving at high speed [7]. The use of porous asphalt can be used for moderate traffic such as rural roads, parking lots, or roads that have other moderate loads. In the Marshall test without the addition of plastic waste and HDPE plastic additives as well as Marshall for each material the optimum bitumen content (KAO) value will be considered, from the Marshall test which includes Stability, *Flow*, VIM at the planned asphalt content, according to previous researchers, reached 5% [8]. Porous asphalt is a mixture of asphalt with a low percentage of fine aggregate, resulting in large voids. Porous asphalt consists of a greater proportion of coarse aggregate to have water absorption capacity according to [9]. The research objectives in this study were (1) Knowing the characteristics of the constituent materials of porous asphalt mixtures. (2) Knowing the effect of adding ABS plastic (*Acrylonitrile butadiene styrene*) in the optimum mixture of porous asphalt against Marshall characteristics. According to (Pratomo et al., 2016) [10] using asphalt concrete with additional aggregates from LDPE AC – WC plastic waste, the KAO strength value (optimum asphalt content (2.-6%) with LDPE value (2 – 6%). Based on the results of research characteristics Porous asphalt which includes coarse, fine aggregate and filler has met the standards which use RSNI 2019 [11].

2. Research Methods

Research using experimental methods on testing porous asphalt with ABS plastic additives. Asphalt 60/70 is asphalt that is generally used in Indonesia. The research was carried out in the Tribhuwana Tunggadewi University campus area (Transportation and Roads Laboratory). This type of research is quantitative research because this research is a type of research whose specifications are systematic, planned, and structured from the start to the creation of the research design. This research required a certain duration of time, starting from the process of preparation, manufacture and testing of porous asphalt. In a study so that the expected goals are achieved. So this can be obtained by studying books, laboratory data and information from the internet. To make it easier to identify and solve each problem and produce appropriate output, a research flowchart has been prepared. For more details, it can be seen in Figure 1.

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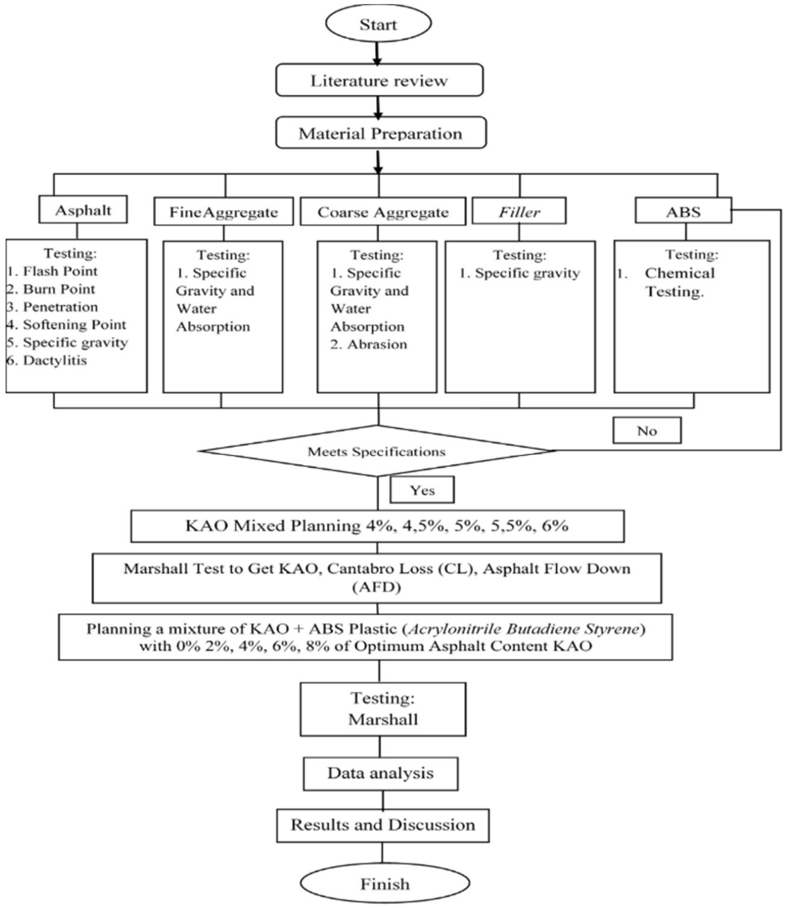

Figure 1. Research Flowchart

The aggregate gradation plan used in the study is shown in Table 1, where this test is based on specifications *Australian Asphalt Pavement Association (AAPA)* 2004. [12]

Table 1. Aggregate gradation of porous asphalt mixture (AAPA) 2004

Filter Number	Sieve Size(mm)	Specifications	% Pass	% Restrained	Weight (grams)
¾	19,0	100	100	0	0
½	13,2	85-100	90	10	120
3/8	9,5	45-70	58	32	384
No. 4	4,75	10-25	17	41	492
No. 8	2,36	7-15	11	6	72
No. 16	1,18	6-12	9	2	24
No. 30	0,6	5-10	7	2	24
No. 50	0,3	4-8	6	1	12
No. 100	0,15	3-7	5	1	12
No. 200	0,075	2-5	3	2	24
PAN	0	0	0	3	36
Total Weight					**1200**

The asphalt used in this study is hard asphalt with a penetration of 60/70. This test is based on the AAPA 2004 specifications

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Table 2. Specifications for testing the characteristics of asphalt AAPA 2004

No	Test Type	Unit	Condition		Unit
			min	maks	
1	Penetration	mm	60	79	Mm
2	Soft Point	° C	48	58	^{O} C
3	Flash point	° C	200	-	^{O} C
4	Burn point	° C	200	-	
5	Specific gravity	gr/cm3	1	-	
6	Ductility	cm	100	-	

This research was carried out by making test objects and analyzing the results of the research. The research design to be carried out can be seen in Table 3

Table 3. Research design (Mix Design)

No	Test Object Code	Optimum Asphalt Content (%)	KAO weight (gr)	ABS Rate (%)	ABS weight (gr)	Number of Test Objects	Total ABS Needs (gr)
1	PL.0	5,00	60	0%	0,00	3	0,00
2	PL.2	5,00	60	2%	1,20	3	3,60
3	PL.4	5,00	60	4%	2,40	3	7,20
4	PL.6	5,00	60	6%	3,60	3	10,80
5	PL.8	5,00	60	8%	4,80	3	14,40
Total Marshalls						**15**	**36,00**
Total Overall Test Objects						**46**	**36,00**

3. Regression Analysis

Regression analysis used to determine the relationship pattern or relationship between the dependent variable and the independent variable. The use of this regression line was chosen because this regression analysis model is considered very strong and flexible. After all, it can correlate a large number of independent variables with the dependent variable. A dependent variable and independent variable have a significant correlation which is tested through the probability of alpha error. The variable that is predicted is called the criterion and the variable that is used to predict is called the predictor. The correlation between the criterion variable and the predictor variable can be described in a regression line. The regression line being analyzed is a linear regression line expressed in a mathematical equation called the regression equation. The main tasks of regression analysis are:

1. Look for correlations between criteria and predictors
2. Test whether the correlation is significant or not
3. Look for the regression line equation
4. Finding the relative contribution between predictors if the predictor is more than AAPA 2004

$$y = a + bx \qquad (1)$$

Information:
y = asphalt content value
x = value of plastic content

The regression line equation is obtained from a set of data which is then arranged into a scatter diagram (*scattered*). From this diagram, with the help of Microsoft Excel, a linear regression line can be made, and then from the regression line, the regression equation and the coefficient of determination are obtained.

In the band diagram method, the results of research in the laboratory are the Marshall test

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parameters (VIM, VMA, stability, *flow*, MQ) as the Y axis is plotted with the variation of tested asphalt content as the X axis. Then the value of asphalt content is searched for which all the Marshall test parameters meet to obtain the optimum asphalt content (KAO). Likewise, by obtaining the proportion of plastic content, the Marshall test parameters (Y-axis) were plotted with variations in the proportion of plastic content tested (X-axis).

4. Results and Discussion

The research results are explained in full according to the method used. An in-depth discussion is carried out based on data from surveys, tests, or other data collection methods. The discussion must relate the content to the theory that has been put forward before. If a lot of result data is displayed, Results and Discussion/Analysis can be listed in different sections.
The results of aggregate testing in the laboratory that will be used must meet the specifications*Australian Asphalt Pavement Association* (AAPA) 2004 for use as a road pavement material for porous asphalt mixtures as shown in Table 4.

Table 4. Coarse and Fine Aggregate Test Results

No	Testing	Unit	Specification*		Results	Information
			Min	Maks		
			Coarse Aggregate			
1	BJ Bulk	(gr/cm^3)	2,5	-	6,51	Fulfil
2	BJ SSD	(gr/cm^3)	-	-	6,54	Fulfil
3	Pseudo BJ	(gr/cm^3)	-	-	6,70	Fulfil
4	Absorption	%	-	3,0	0,45	Fulfil
5	wear and te	%		40	20,06	Fulfil
			Fine Aggregate			
1	BJ Bulk	(gr/cm^3)	2,5	-	6,56	Fulfil
2	BJ SSD	(gr/cm^3)	-	-	6,56	Fulfil
3	Pseudo BJ	(gr/cm^3)	-	-	6,44	Fulfil
4	Absorption	%	-	3,0	2,16	Fulfil

Asphalt material does not meet predetermined specifications, it can reduce the performance of the porous asphalt mixture in supporting the vehicle load on it. Below will be explained further about asphalt testing in Table 5.

Table 5. Asphalt Testing Results

No	Testing	Unit	Specification*		Results	Information
			Min	Maks		
1	Specific gravity	(gr/cm^3)	1	-	1,034	Fulfil
2	Penetration	(mm)	60	79	66,70	Fulfil
3	Soft Point	(˚C)	48	58	55	Fulfil
4	Flash point	(˚C)	200	-	265	Fulfil
4	Burn Point	(˚C)	200	-	285	Fulfil
5	Ductility	(cm)	100	-	240	Fulfil

Testing optimum asphalt content that has been carried out obtains the parameters namely VIM*, VMA,* stability, *flow*, and marshall *quotient*. The results of the calculation analysis of these parameters can be seen in Table 6 and Figure 2-6

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Table 6. Test Results for ABS Levels

No	Testing	Unit	Specification*		Results
			Min	Maks	
1	*VIM*	(%)	18	25	18,55-23,61
2	*VMA*	(%)	-	15	25,15-27,2
3	Stability	(kg)	500	-	268,28-924,95
4	*Flow*	(mm)	2	6	2,5-4,37
5	*Marshall Quotient*	(Kg/mm)	250	-	70,79-364,07

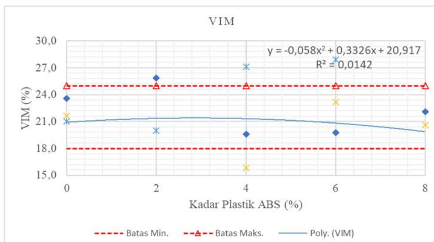

Figure 2. VIM

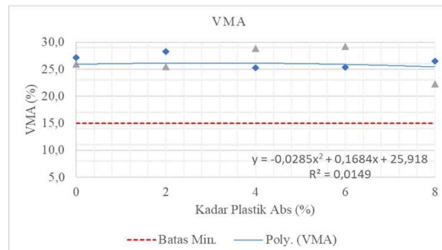

Figure 3. VMA

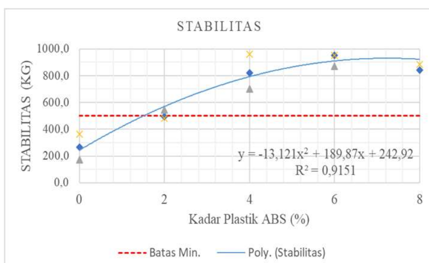

Figure 4. Stability

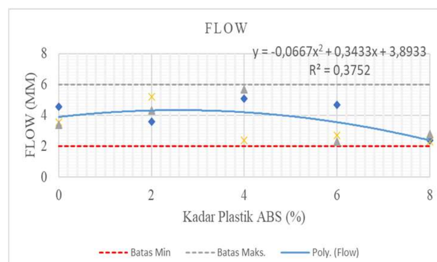

Figure 5. Flow

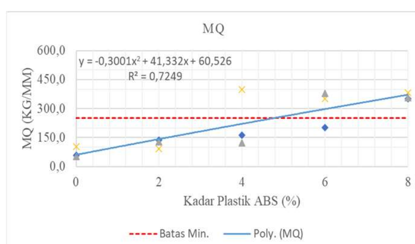

Figure 6. Marshall Quotient

Table 7. Band diagram for determining ABS content

Marshall Parameters	Specification	Test result			ABS Content (%)				
					0	2	4	6	8
VIM (%)	18 - 25	18,55	-	23,61					
VMA (%)	15	25,15	-	27,2					
Stability (Kg)	Min. 500	268,28	-	924,95					
Flow (mm)	02-Jun	2,5	-	4,37					
MQ (Kg/mm)	Min 250	70,79	-	364,07					

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VIM or Void in Mix is the pore volume that remains after the asphalt mixture is compacted and is needed for the shifting of aggregate grains. *VIM* affect the durability of the pavement layer. The higher the value *VIM* indicates the greater the cavity in the mixture so that the mixture is porous. And if value *VIM* which is too low will cause bleeding. According to [4] value *VIM* generally decreased with increasing asphalt content. This is comparable to research [13] adding coal fly ash content makes the VIM value decrease at the optimum mixed content of 7% with a value of 4.69%. This proves that as the mixture is added, the voids in the mixture become increasingly filled. At all asphalt content, the VIM value meets the specification requirements *Australian Asphalt Pavement Association* (AAPA) 2004, the requirements for VIM values in porous asphalt mixtures are 18 - 25%. In general, the more ABS content is added, the VIM value will decrease, this indicates that ABS fills the voids in the aggregate. VIM testing (Sa'dillah, 2023) with variations in LDPE content from 0% to 8% showed that with increasing levels, the porous asphalt mixture increased because the addition of LDPE plastic waste made the mixture more porous [14]. VIM testing (Sa'dillah, 2021) with the addition of concrete waste has increased because the mixture with the addition of concrete waste makes the mixture better. The highest VIM value that meets the requirements of the Australian Asphalt Pavement Association (AAPA) 2004 specifications is at a concrete waste content of 80% with a value of 20.25%[15]

VMA or *Void in Mineral Aggregate* is the pore volume that remains after the asphalt mixture is compacted and is needed for the shifting of aggregate grains. VMA value affects the durability of pavement layers. The higher the value *VMA* indicates the greater the cavity in the mixture so that the mixture is porous. And if the value *VMA* is too low will cause *bleeding*. According to [4] value, *VMA* generally decreased with increasing asphalt content. At all asphalt content, the VMA value meets the specification requirements *Australian Asphalt Pavement Association* (AAPA) 2004, the requirement for VMA values in porous asphalt mixtures is > 15%.

The value of stability is influenced by the shape, quality, surface texture and aggregate gradation, namely friction between aggregate grains and inter-aggregate locking, adhesion, and bitumen content in the mixture. The use of asphalt in the mixture will determine the stability value of the mixture. With the addition of bitumen, the value of stability will increase to the maximum limit. The addition of asphalt above the maximum limit will cause a decrease in the stability of the mixture so that the pavement layer becomes stiff and brittle. The stability value affects the flexibility of the resulting pavement layers. Research conducted [16] states that coal fly ash filler can withstand the influence of temperature in the field, by making the pavement more rigid, so that the pavement becomes more resistant to deformation. This can be seen from the stability value on the test object of 1,326 kg. The highest stability value on the research test object was 924.95 kg at 8% ABS content. The entire research test object still meets the requirements specified by the Australian *Asphalt Pavement Association* (AAPA) 2004, namely stability values for porous asphalt mixtures > 500 kg, except at 0% content.

Flow on the Marshall characteristic test with the composition of ABS plastic pellets. The test results flow with conditions Australian *Asphalt Pavement Association (AAPA 2004)* 2-6, namely the level that passes or meets the specifications of AAPA (2004) at 0% ABS asphalt content, which is 3.83 mm, and at an increased 2% ABS content, a value of 4.37 mm is obtained, 4% ABS content obtains a value of 4.40 mm, the 6% ABS plastic content decreased to a value of 3.23 mm and the 8% ABS content decreased to a value of 2.50 mm. So on to testing low with the addition of ABS plastic and asphalt, there were ups and downs at levels of 0%, 2%, 4%, 6% and 8%. If in testing porous asphalt with additives ABS plastic seeds value *Flow* meets, then porous asphalt can be used in the world of construction in the field of pavement. However, mixtures that have a low fatigue number with high stability tend to be stiff and brittle. Meanwhile, mixtures that have high fatigue rates and low stability tend to be plastic and easily deform when subjected to traffic loads. Good mix density, sufficient asphalt and good stability will affect the value flow.

Marshall quotient in the tests carried out continued to increase along with increasing levels of ABS. This is inversely proportional to research [10] which tested stated values *marshall quotient* continued to decrease as the amount of concrete waste increased. Lowest value*Marshall quotient* namely with a value of 70.79 kg/mm. The highest value marshall *quotient* meets the requirements with a value of 367.07 kg/mm. The levels of research test objects of 6% and 8% still meet the requirements specified by the Australian *Asphalt Pavement Association* (AAPA) 2004 namely the

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value marshall *quotient* for a minimum porous asphalt mixture of 250 kg/mm, except for 0%, 2% and 4% content.

5. Conclusions

The effect of adding ABS plastic pellets on the performance of porous asphalt was obtained with an optimum ABS plastic content of 6% with a VIM value at 6% content of 23.61%, a VMA value of 27.20%, for a stability value of 924.95 kg and the flow value obtained is 3.23 mm while the MQ value is 311.15 kg/mm and meets the specifications *Australian Asphalt Pavement Association (2004)* with the research stages, namely the Marshall test covering stability, flow, VIM, VMA and MQ, a mixture of porous asphalt added with ABS plastic can increase the stability and MQ values where the VIM, VMA and flow values decrease, pavement that has high stability and is more rigid will has a low back-deforming ability, and conversely a pavement that has low stability and is more flexible as a high back-deformation ability.

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