Optimation of Asphalt Bituminous Coal and Resiprene Composition to Improving the Physical Properties and Morphological of Paving Block

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Abstract: The research has been done about the preparation of paving block with varied of composition Asphalt, Bituminous Coal, and Resiprene. Which asphalt is used as a binder replacement. This research aims to determine the optimum value of material produced to improving physical and morphological properties. Paving block are prepared by mixing asphalt, bituminous coal, resiprene and DCP (Dicumil Peroxide) as an inisiator and DVB (Divinil Benzene) as a crosslinker. Mixing using an internal mixer with the addition of aggregates and then shaping/forming process. The results of characterization obtained optimum value of physical properties at the variation of asphalt : bituminous coal : resiprene (70 : 5 : 25). The results of morphological characterization using by SEM (Scanning Electron Microscopy) show that the mixture with the most optimum physical properties is the most homogeneous. Maximum compressive strength value 5.885 Mpa and water absorption value 0.90%.

1 INTRODUCTION

The development of science and technology has an influence on progress in all fields, one of which is in the field of development. Where the rapid development of development will affect the smooth running of community activities. One of the developments that influences the smoothness of community activities is the construction of road violence. One of the materials for road violence is paving blocks. Paving block is defined as a composition of building materials made from a mixture of Portland cement or similar hydraulic adhesives, water and aggregates with or without other added ingredients that do not reduce the quality of the paving blocks (SNI 03-0691-1996). Paving blocks are one of the elements of building materials that are widely used as a coating of road pavement. Generally used for yard pavement, parking lots or for environmental roads. Paving blocks must meet the quality of building materials that will be used as road pavement coatings. One of the quality characteristics that paving blocks must have is compressive strength. The quality of paving blocks will be better if it has a higher compressive strength (Murdiyoto, 2011) .

Research on paving blocks has been carried out by adding or replacing constituent components in paving blocks. One of them is the use of red brick as a substitute for cement (Wikana & Gulo, 2012) and the addition of coconut shell ash.

Asphalt can also be used as a substitute for cement. Asphalt mixing in the paving block is done so that the interaction occurs. Asphalt is used because it contains hydrocarbons. Utilization of asphalt waste from cold milling as added material for making paving.

The results obtained show that a good mixture of paving with the addition of asphalt cold milling results of 35% produces a compressive strength of 11.11 MPa, and an average water absorption of 4.5174. The yield of compressive strength with the addition of 35% bitumen is greater than that required by SNI 03-0691-1996, which is 10 MPa (Karnanta, 2014).

Over time and the influence of weather changes can cause physical damage from paving blocks. Therefore it is necessary to improve the physical properties of paving blocks where physical properties are influenced by mechanical and morphological properties.

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As for those that can affect the physical properties of paving blocks, namely modification using polymeric materials such as polyethylene, the addition of polyethylene affects the compressive strength yield where the compressive strength produced is increasing because polyethylene has high crystallinity and high tensile strength between molecules and also polyethylene has a porous structure so that it can reduce water absorption in paving blocks (Hambali et al., 2013).

Modification of paving blocks using crumb rubber as an aggregate to produce tactile paving blocks. The addition of crumb rubber has an effect on the yield of compressive strength and better abrasion resistance (Silva et al., 2015).

In addition, the material used for the modification of paving blocks is bitumen. Bitumen is a low-cost thermoplastic material that is widely used in roofing, road and pavement applications. Has a unique combination of perfect waterproof and adhesive properties that have been used effectively for more than 5000 years. However, bitumen has weak mechanical properties which are easily brittle in cold conditions and can quickly soften and thaw in hot conditions. One method used to strengthen bitumen is mixing it with polymeric materials (McNally, 2011).

Bitumen modified with GMA-g-LDPE has better rutting properties at high temperatures and melting. Crack resistance at low temperatures compared with bitumen modified with LDPE results obtained are lower (Li et al., 2007). Modification of bitumen by using asphalt can increase water absorption, compressive strength and morphology of road pavement materials. The bitumen used is liquid bitumen (Marantika, 2017).

Making polymer asphalt by using SIR-20 rubber as an additive in the presence of DCP and DVB using the extrusion process can improve its characterization (Azliandry, 2011).

As for the cyclic rubber is reciprocator. Resiprene is a cyclic rubber resin from natural rubber that has a high solution viscosity, made like granular solids. The recipient can act as an adhesive in a material (Bukit, 2011). Mixing recipients and bitumen gives a better effect on the improvement of mechanical properties of the resulting pavement layers and better morphological properties (Marantika, 2017).

Chemical modification on rubber needs to be done, this is because if the mixture consists only of asphalt, rubber, and aggregates then only physical bonding occurs. Chemical modification in rubber can be done by cluster grafting techniques. Grafting technique is one method that is simple, easy, and has been done a lot. The use of dicumil peroxide (DCP) initiator with divinyl benzene (DVB) crosslinker on asphalt and rubber mixture will encourage chemical bond between asphalt, rubber and aggregate.

This is because both the rubber polymer and asphalt will be radical (Ritonga et al., 2018).

Based on the description above, the writer wants to do research on Optimization of Asphalt Bituminous Coal and Resiprene Composition to Improve the Physical Properties and Morphological of Paving Block.

2 RESEARCH METHODS

2.1 Material

Bituminous coal from PT. Amber and Coal Sumatra, Asphalt from Iran Type Grade 60/70, Resiprene from Resiprene 35 Factory, Toluent, Divinylbenzene (DVB) from Sigma-Aldrich, Dikumil Peroxide (DCP) from Sigma-Aldrich, Aggregate from Pebble Stone from CV. Setia Jaya, Fine Sand Aggregate from CV. Faithful Jaya.

2.2 Process of Making Paving Blocks

A total of 5 grams of recipient was put into the erlenmeyer and dissolved with toluene while heated and stirred with a magnetic stirer. Then put asphalt into the glass beaker while heated. Then both of them were mixed while being heated at 140 ^{0}C for 15 minutes, then added 25 grams of bituminous coal while stirring. The mixture was added 0.9 ml DVB and stirred for 10 minutes. 300 grams of sand and 50 grams of gravel were added to the mixture while still stirring, then added 0.9 grams of dcp while still stirring for 10 minutes under the same heating. The mixture is then put into a cube mold. Then the molds are put into a hydrolytic press which has been set at 140^{0}C for 30 minutes, then cooled to room temperature.

Table 1: variations of asphalt, bituminous coal and resiprene.

Asphalt (mL)	Bituminous coal (gram)	Resiprene (gram)
70	*20*	*10*
70	*15*	*15*
70	*10*	*20*
70	*5*	*25*
70	*0*	*20*
80	*20*	*0*

2.3 Water Absorption Test

Water absorption test refers to the SNI-03-0691 standard with the following procedure: the tested sample is immersed in water for 24 hours and then dried. To calculate the absorption value of water with the following formula:

$$WA = \frac{(M_j - M_k)}{M_k} \times 100\% \quad (2.1)$$

with:
WA = water absorption
M_k = dry sample mass
M_j = saturated mass of water
(Butar-butar, 2009)

2.4 Compressive Strength Test

Compressive strength testing refers to ASTM D7901 / C293, carried out with the AL-7000M GOTECH apparatus by giving a load of 20 kN or 2039.4 Kgf, with the following procedure: the tested sample is placed on a compressive strength testing machine. Loading is done slowly until the test specimen is destroyed, ie when the maximum load is working. The maximum load is recorded as Pmax. Compressive strength test is calculated using the following formula:

$$P = \frac{F}{A} \quad (2.2)$$

with:
P = compressive strength, N / m^2
F = maximum force of the press, N
A = cross-sectional area stressed, m^2
(Butar-butar, 2009)

2.5 Scanning Electron Microscopy (SEM) Test

The test is carried out on the sample surface with the following procedure: the sample is coated with gold mixed with palladium in a pressure chamber (vacum evavorator), then irradiated with secondary electron beam and bounced electrons which can be detected by scientor detectors which are amplified with an electrical circuit that causes the cathode ray tube (CRT).

The results of the shooting are done after selecting a particular part of the object (sample) and enlarged until a good and clear photo is obtained.

3 RESULTS AND DISCUSSION

3.1 Water Absorption Analysis

A water absorption test has been carried out by immersing the sample for 24 hours on all types of sample variation, where the test results are substituted into equation 2.1. In order to obtain the percentage of absorption shown in tabular form as below.

From the Table 2, it can be seen the relationship between the percentage of water absorption with variations of asphalt, bituminous coal and resiprene displayed in graphical form.

Table 2: Water Absorption Values for Asphalt, Bituminous Coal, and Resiprene Variations.

NO	Variation	DCP (Dicumil Peroxide) (gram)	DVB (Divinil Benzene) (mL)	Specimen Mass (gram)		Difference	WA (%)
	Asphalt:BP:Resiprene (mL:gram:gram)			Mk	Mj		
1	70:25:5	0.9	0.9	272.76	277.55	4.79	1.75
2	70:20:10	0.9	0.9	276.15	280.47	4.32	1.56
3	70:15:15	0.9	0.9	276.88	280.44	3.56	1.28
4	70:10:20	0.9	0.9	273.69	276.96	3.72	1.19
5	70:5:25	0.9	0.9	271.16	273.62	2.46	0.90
6	80:0:20	0.9	0.9	272.15	280.16	8.01	2.94
7	80:20:0	0.9	0.9	273.07	279.34	6.27	2.29

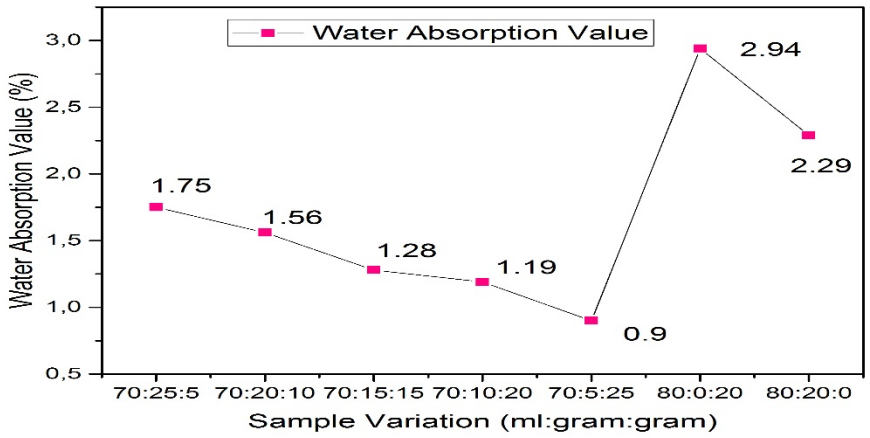

Figure 1: Relationship between Water Absorption Value and Asphalt, Bituminous, and Resiprene.

The results are continued in graphical form, it shows a decrease which shows that with increasing resiprene, the water absorption in the sample will decrease, where the recipient serves as waterproof in the paving block sample. And also with the addition of bituminous coal also reduces the value of water absorption, this is because bituminous is resistant to water (McNally, 2011).

In the initial weighing ratio of 70: 25: 5 the mixture of asphalt, bituminous coal and resiprene with the addition of DCP and DVB is 272.76 grams but after soaking for 24 hours the weight obtained is 277.55 grams there is a difference of 4.79 grams or absorption sample water at 1.75%. At a ratio of 70: 5: 25 asphalt mixture, bituminous and resiprene with the addition of DCP and DVB initial weight of 271.16 grams and weight after immersion of 273.62 grams there is a difference of 2.46 or a water absorption capacity of 0.90%.

According to SNI 03-0691-1996 paving block water absorption there are 4 qualities namely quality A used for roads has an average water absorption of max 3%, quality B used for parking lots has an average water absorption of max 6%, quality C is used for pedestrians have an average water absorption of max 8%, and quality D is used for parks and other users have an average water absorption of max 10%.

This shows that all samples that have been tested with water absorption have met the requirements according to the Indonesian National Standard.

3.2 Compressive Strength Analysis

Compressive strength testing has been carried out on all samples by giving a load of 2000 Kgf and a speed of 10 mm / min. The test results are displayed in tabular and graphical form. The results of compressive strength measurements from the Paving Block shown in the table shows that with the increase in percent recipients added, the compressive strength values tend to increase.

Where the optimum variation in the mixture of asphalt, solid bitumen, and recipient with the addition of DCP and DVB 70: 5: 25 with a strong stress value of 5.885 MPa. From the sample variations, the optimum combination of ingredients in the paving block is obtained. As for the Asphalt, Bituminous coal, without the addition of resiprenet, the compressive strength value of 0.103 MPa.

Based on the graph, it can be seen that the increasing number of resiprene shows an increase in compressive strength, but after the recipient is not added to the paving block mixture, a decrease in compressive strength occurs. In this case it is clear that the addition of polymer materials around 2-6% is enough to improve the quality of the asphalt mixture (Palacco & Berlincioni, 2005).

Table 3: Compressive strength Value of Asphalt, Bituminous Coal and Resiprene.

No	Variation Asphalt:BP:Resiprene	P	A	Compressive Strength
	(mL:gram:gram)	(Kg)	(mm^2)	(Mpa)
1	70:25:5	68.078	25000	0.267
2	70:20:10	435.559	25000	1.709
3	70:15:15	800.171	25000	3.139
4	70:10:20	864.328	25000	3.391
5	70:5:25	1499.891	25000	5.885
6	80:0:20	26.165	25000	0.574
7	80:20:0	146.313	25000	0.103

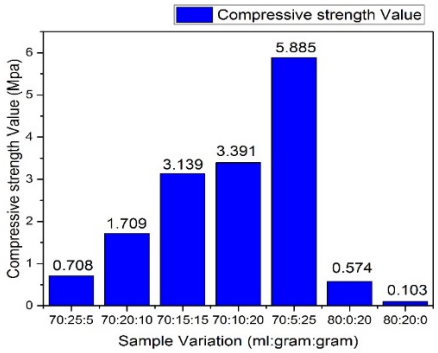

Figure 2: Compressive Strenght Grafic.

3.3 Scanning Electron Microscopy Analysis

SEM analysis is one type of microscope that is able to produce high resolution from the image of a sample surface. The results of the SEM analysis can provide information about the shape and surface changes of the material being tested. Therefore the resulting image has qualitative characteristics in two dimensions because it uses electrons instead of light waves and is useful for determining the surface structure of a sample. Testing with SEM was carried out to determine the surface structure of the sample and was carried out on a mixture of asphalt, solid bitumen and recipient. Tests carried out at magnification 500 times.

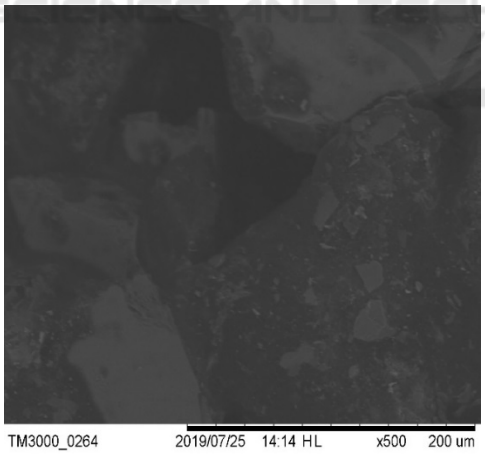

Figure 3: SEM Photo Results of Bituminous coal Asphalt, and Resiprene Mixture 80: 0: 20.

The SEM results shown in Figure 3 are the results of SEM photographs on the surface between the composition of the mixture of paving block material from a mixture of asphalt, bituminous coal, and resiprene with a ratio of 80: 20: 0 and the addition of DCP and DVB with a magnification of 500 times. Based on SEM micrographs in this variation show a lack of homogeneity from asphalt mixing and reciprocity. This is indicated by the existence of large piles that are not attached to each other and also there is a small pile that is an aggregate, where the aggregate looks more attached to the recipient components.

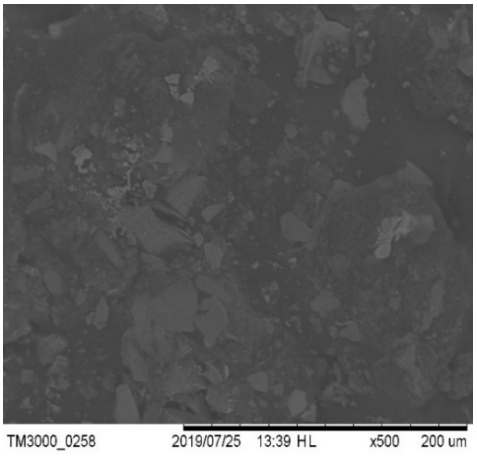

Figure 4: Results of SEM Photos of Asphalt, Bitumen, and Resiprene Mixtures 70: 25: 5.

The SEM results shown in Figure 4 are the results of SEM micrographs of a mixture of asphalt, solid bitumen, and resiprene with a ratio of 70:25: 5 and the addition of DCP and DVB at 500 times magnification. In this variation the asphalt component, dense bitumen and resiprene appear to be sticking together.

This shows the difference from the results of previous micrographs that are not mutually attached. There are small collisions that are evenly distributed, this shows the aggregate has been attached to the components of asphalt, bituminous coal and resiprene evenly.

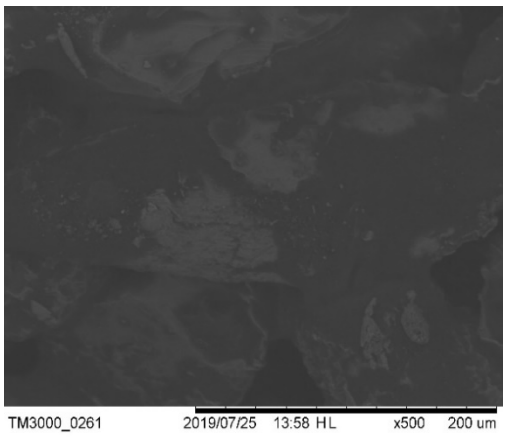

Figure 5: Result of SEM photo of Asphalt, Bituminous Coal, and Reciprene Mixtures 70 : 5 : 25.

The SEM shown in Figure 5 is the results of SEM micrographs from a mixture of asphalt, bituminous coal, and resipren in a ratio of 70: 5: 25 and the addition of DCP and DVB at 500 times magnification. The magnitude of the rubber content also affects the homogeneity of the paving block sample, where in this variation 25% rubber is added.

Based on the results of SEM migrographs in Figure 5 show that homogeneity in Figure 5 is more effective than in Figure 4. In this variation also no visible small piles which are aggregates as seen in Figures 3 and 4. This indicates that the aggregate has been mixed into all components, both asphalt, bituminous coal, and resiprene.

4 CONCLUSIONS

Utilization of asphalt, bituminous coal, and recipient can improve the physical and morphological characteristics of the paving blocks produced with the optimum ratio of asphalt, solid bitumen and resiprene (70: 5: 25). The physical properties of the water absorption capacity of the samples produced the best water absorption of 0.90% and mechanical properties at the optimum compressive strength of 5.885 MPa.

Morphological characteristics of the characteristics of SEM (Scanning Electron Microscopy) test showed a difference in surface structure by comparison of the composition of the material used. Where the mixing results with homogeneity of the most effective structures at the optimum ratio.

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