The Aging Properties Of Thin Surfacing Hot Mix Asphalt Containing Crumb Rubber As Aggregate Replacement

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Abstract : One of the main factors of road damage is the old age of the road. Road damage due to the age of the old road that causes friction of vehicle tires and the road is getting wider resulting in the use of tires on the vehicle which is easily damaged and causes a lot of used tire waste. Crumb rubber is a waste material that has flexible properties; this material can be used as a substitute for fine aggregate in the asphalt mixture layer. This research was conducted to find the optimum contents of asphalt and crumb rubber in asphalt mixtures that have been given aging behavior with the Long-term Aging Method (Long Term Oven Aging) and was tested by using Marshall test. Finally, it is concluded that the value obtained results in a good value at Marshall value which reduces the risk of emptiness in mixed pores and the addition of crumb rubber mixed with pavement on the road with the aging behavior can still be used for main roads with special requirements, such as playgrounds, jogging paths, or small roads.

Keyword : Asphalt, Crumb Rubber, Aging, Marshall Test

1. INTRODUCTION

Main road is the transportation infrastructure that plays a strategic role in the social, economic and cultural fields. It serves 80-90% of all goods and people transportation in Indonesia, so that the construction of road transportation infrastructure is a prioritized development sector. The rapid growth of traffic in Indonesia is a major factor in shortening the service life of land transportation infrastructure to meet these demands. It is necessary to seek efficiency in various components of road construction, either from pavement construction materials, equipment used or other construction costs. The use of hot asphalt mix surfaces is one of the alternatives that can be used to anticipate the increased pavement surface problems due to conventional overlay. Thin surfacing hot mix asphalt is a technology which is being developed by the researchers in an effort to improve the quality of maintenance and coat the pavement of the damaged surface. [1-4]. The use of crumb rubber as an asphalt mixture is also expected to reduce the use of excessive petroleum asphalt, so that it can save asphalt which is a non-renewable natural resource. Crumb rubber in Indonesia can be obtained easily from craftsmen or materials from the tire retreading industry, so that it is expected that the research results can recycle the use of materials that are not used and can be utilized in civil engineering [5]. Previous studies have been done to assess the compatibility of the use of crumb rubber in the design of road materials [6-9]. Giving asphalt aging by being heated in the oven for 48 hours provides aging effect as in the field for 5 years [10].

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2 EXPERIMENTAL

2.1 Aggregate Test

Coarse aggregate testing was carried out at the Sebelas Maret University's Main Road Laboratory. The coarse aggregate tested in this study was from PT. Panca Darma Puspawira which had an angular shape and rough texture. Coarse aggregate inspection included bulk density, SSD density, apparent density, absorption, and abrasion value. The results of the coarse aggregate (CA) testing can be seen in Table 1.

***Table** 1. The Properties of Coarse Aggregate*

No	Type of Test	Coarse Aggregate	
		Specification	Result
1	Adsorption (%)	Max. 3.0	2.51
2	Bulk Density (gr/cc)	Min. 2.5	2.51
3	SSD Density (gr/cc)	Min. 2.5	2.57
4	Apparent Density (gr/cc)	-	2.68

The characteristic testing of used tires as substitutes for fine aggregate aims to determine the specific gravity of used tires itself. It is expected that used tires can be applied as substitutes for fine aggregates. Used tire testing was carried out at the Sebelas Maret University's Main Road Laboratory. Used tire aggregates tested in this study were obtained from used tire craftsmen in Kalibogor Banyumas area in powder form according to fine aggregate gradation. Fine aggregate testing includes bulk density, SSD density, apparent density, absorption, and abrasion value. The results of the coarse aggregate (CA) testing can be seen in Table 2.

***Table 2**. The Properties of Fine Aggregate*

No	Type of Test	Coarse Aggregate	
		Specification	Result
1	Adsorption (%)	Max. 3.0	2.09
2	Bulk Density (gr/cc)	Min. 2.5	2.66
3	SSD Density (gr/cc)	Min. 2.5	2.70
4	Apparent Density (gr/cc)	-	2.88

2.2 Asphalt Test

The asphalt used in this research is Pertamina 60/70 asphalt. Asphalt testing includes testing of Penetration, Ductility, Softening points, Flas points, Burning points, Specific Gravity, Affinity. All asphalt testing must meet the requirements based on SNI (Indonesian National Standard) in accordance with their respective testings so that asphalt can be used in this research. The properties of 60/70 pen asphalt are tested by using Indonesian Standard Test and presented in Table 3.

***Table 3**. The Properties of 60/70pen Bitumen*

No	Type of Test	Value	Unit	Specification	
				Min	Max
1	Penetration	69.7	0.1 mm	60	79
2	Ductility	>150	Cm	100	-
3	Softening Point	48	Celcius	48	58
4	Flash pointt	257.5	Celcius	200	-
5	Burning point	325	Celcius	200	-
6	Specific Gravity	1.038	g/cc	1	-
7	Affinity	98	%	95	-

2.3 Combined Grading

The standard manufacture job of mixed asphalt aggregate substitute refers to the Standard To obtain satisfactory results, the mixture must be designed to meet all the requirements given in RSNI 03-1737-1989 specification., while the testing of the specimen is based on the standards issued by the Asphalt Institute Superpave Series 1 (SP -1) and adopting the method which is standardized by the Directorate General of Highway in the form of National Indonesian Standard (SNI). This research was done by testing asphalt as a preliminary test and testing a mixture of Marshall Characteristics. Marshall test was performed to obtain density, porosity, stability, flow, and Marshall Quotient which then asphalt content and optimum crumb rubber content can be calculated and obtain. Thin surface gradations are presented in Table 4.

***Table 4**. RSNI 2010 revisi 3*

No	Sieve Size (mm)	Specification		Gradation Used
		Min	Max	
1	3/4 (19 mm)	100		100
2	1/2 (12.7 mm)	90	100	91.45
3	3/8 (9.51 mm)	75	85	82.21
4	8 (2.38 mm)	50	72	61.43
5	30 (0.6mm)	35	60	38.52
6	200 (0.074 mm)	6	12	7.84

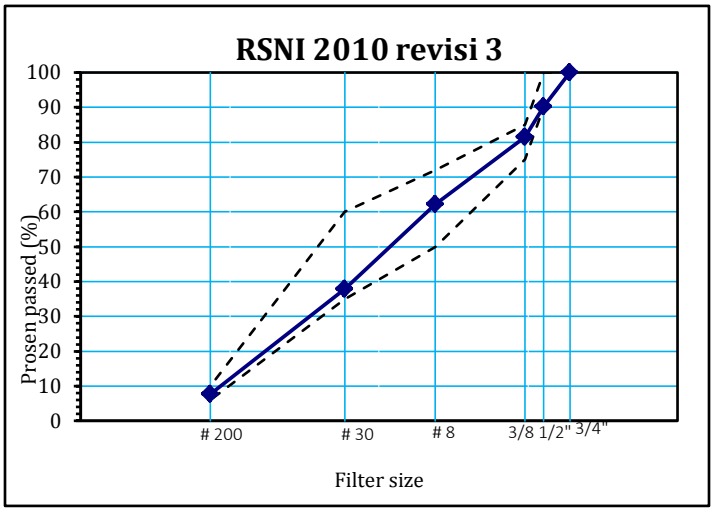

***Fig 1**. Nort Carolina This Surfacing Gradation*

2.4 Crumb Rubber

Crumb rubber in this research is rubber from used tire waste, hereinafter referred to as used rubber. In general, after being unused, rubber waste from motor vehicle tires is thrown away. The accumulation of rubber waste at the final disposal site will cause new problems because this waste is difficult to decompose. The part of the tire namely Tread functions as the tire coating. This layer is in the form of a soft rubber sheet so that it is easy to shape. This layer does not get as much attention from people. This rubber solid tire material's elasticity is most likely to be used as an asphalt mixture, because it has the same properties as natural rubber. Because the rubber layer is still solid, in experiments in the laboratory, the rubber is chopped up to be shaped like sand and mixed with asphalt during asphalt frying.

***Fig 2**. Tire compiler section*

Crumb rubber used in this study was obtained from the retreading industry in Kalibogor region, Banyumas, Central Java Province, Indonesia. The size of the crumb rubber used passes through #4 filter and #200 anchor and after being tested for specific gravity, it obtains a value of 1.134 g/cc. Figure I shows the use of crumb rubber in this investigation.

***Fig 3**. Crumb rubber as aggregate replacement made from waste recycled tires*

2.5 AGING

Asphalt mixture aging is caused by two main factors, specifically the evaporation of the light oil fraction contained in asphalt and the progressive oxidation of short-term aging, and the progressive oxidation of long-term aging. The basic method to evaluate Long Term Oven Aging (LTOA) is done by way of taking examples of flexible pavement in the field that has good performance, approximately after 5 years of service that has experienced long-term aging, a mixture of asphalt that is just made but stored first in the oven for two days at 85°C.

***Fig 4**. Samples that have experienced aging STOA for 5 years*

3 RESULTS AND DISCUSSION

The research results on the use of crumb rubber as the substitute for fine aggregate after long-term aging with the Long Term Oven Aging (LTOA) method will be presented from the results of the Marshall test, volumetric test, and optimum rubber content.

3.1 THE EFFECT OF CRUMB RUBBER AS AGGREGATE REPLACEMENT CONTENT ON THE MARSHALL AND VOLUMETRIC PROPERTIES.

Marshall testing uses asphalt contents vary from 3.5%, 4%, 4.5%, 5% and 5.5%. The determination of the crumb rubber content that will be used is calculated from the sum of the sample volume by using the aggregate specific gravity. Before conducting the Marshall test, firstly, volumetric test is done which includes measurements of diameter and thickness and weight in the air, and then the calculations are performed to obtain values of density, SGmix, and porosity. The Marshall test includes testing the stability, flow and Marshall Quotient values. The volumetric and Marshall Test properties are presented in Table 5.

***Table 5**. The result of Marshall test at various bitumen and rubber Content.*

Bitumen content	Stability (kg)	Porosity (%)	Flow (mm)	Density (g/cm3)	MQ (kg/mm)	Rubber Content (%)
3.5	410.80	11.7	1.83	2.06	223.83	0.5
4	638.13	9.0	2.11	2.10	306.59	
4.5	750.45	8.3	2.26	2.09	330.00	
5	631.44	5.0	1.60	2.14	398.17	
5.5	402.36	5.1	1.46	2.11	277.22	
3.5	489.39	12.1	1.56	2.04	322.15	0.3
4	624.00	9.4	2.33	2.12	274.90	
4.5	766.54	8.7	2.40	2.10	320.18	
5	552.027	5.4	2.20	2.09	161.53	
5.5	428.86	5.5	2.03	2.11	210.52	
3.5	421.22	12.5	1.60	2.04	258.64	0.1
4	553.77	9.8	2.05	2.10	268.93	
4.5	716.52	9.1	1.90	2.10	374.54	
5	594.69	5.8	2.10	2.10	286.66	
5.5	512.95	5.9	1.85	2.10	279.21	
5	515.30	12.7	2.25	2.09	244.93	0
5.5	612.87	10.0	2.20	2.08	286.34	
6	742.22	9.3	2.18	2.11	352.46	
6.5	479.09	6.0	2.16	2.06	220.85	
7	388.37	6.1	2.16	2.09	179.86	

The stability in the Marshall test is shown by reading the stability value corrected by the conversion number. The stability value is affected by friction between the aggregate particles (internal friction), locking between the aggregate particles (interlooking) and good binding capacity of the asphalt layer (cohesion). In addition, the compaction process, aggregate quality and asphalt content also affect the stability value. From the testing table above, the effect of crub rubber on asphalt reveals that the more addition of crumb rubber in the mixture, the higher the stability value will be. It is seen that stability has increased with the addition of crum rubber by 0.3% and 0.5% which gets a stability value of 742.22 kg and 766.540 kg. This occurs because the more crumb rubber used in the mixture, the better the asphalt mixture. Furthermore, the crumb rubber will function as an added material to get the bonding power between the aggregate and asphalt.

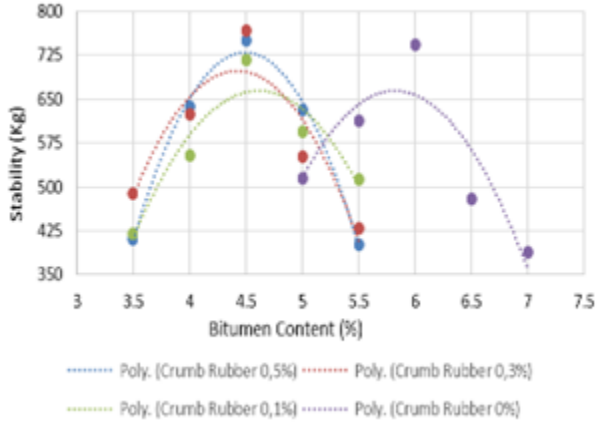

***Fig 3**. The stability of thin surface asphalt mixure at various bitumen and rubber contents*

The effect of aggregate replacement with crumb rubber on volumetric properties is illustrated in Figure 3. It can be seen that the addition of crumb rubber has an effect on the pore cavity value of the mixture. The value of Porosity can be affected by the density and the specific gravity of the mixture. It is seen that the addition of crumb rubber can reduce the value of the empty ratio. From the testing results, it shows that the increase in th crumb rubber contents from 1% to 0.5% leads to reduce the valeue of the air cavity contained in the mixture because crumb rubber functions as a binder that fills the cavity and helps bonding between aggregate and asphalt. Too low porosity value will cause easy bleeding, and vice versa; if the value is too high, its durability will be reduced from the pavement layer because the cavity which is too large will easily enter water and air into the pavement layer.

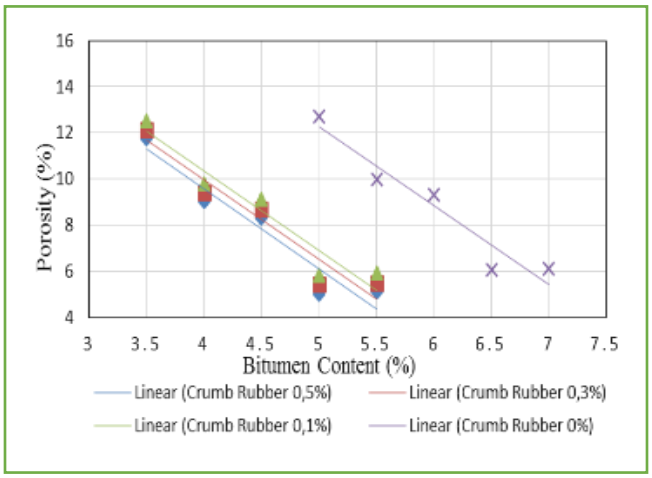

***Fig 4**. The porosity of thin surfacing hot mixture at various crumb rubber aggregate replacement*

3.2 THE EFFECT OF AGGREGAT REPLACEMENT BY CRUM RUBBER ON THE OPTIMAL BITUMEN CONTENT

Optimum asphalt contents are asphalt contents which will produce the best characteristic properties in an asphalt mixture by considering the flow value, porosity density and Marshall Quotient. Optimum asphalt contents are determined based on a derivative/differential (y '= 0) of polynomial regression equation from the graph of the relation between asphalt contents and stability. The results of the regression equation from this study can be seen in the relation between asphalt content and stability calculated as shown in the graph. It can be concluded that the use of larger crumb rubber content contained in the mixture makes it easier to bind the aggregate in the mixture because crumb rubber will also function as a binder on the asphalt mixture. The correlation between crumb rubber contents and asphalt contents to obtain optimum asphalt content can be expressed as y = 12.96x2 - 8.692x + 5656 with R2 = 0.873 as shown in Figure 5. It can be seen that the use of crumb rubber up to 0.3% can reduce the use of conventional petroleum asphalt in use for the development of infrastructure that is more environmentally friendly.

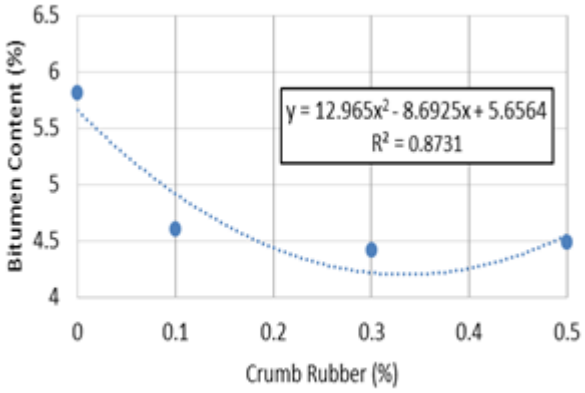

***Fig 5**. The Influenced of aggregate replacement by crumb rubber on the optimum bitumen content*

4 CONCLUSION

The results of the research can be concluded as follows:

1. Stability will increase by adding crumb rubber; this is because adding the crumb rubber contained in the mixture makes the bond's strength between aggregates better.
2. Replacing crumb rubber in the aggregate can be a solution to fill the empty space of the mixture which is affected by the density of the mixture. It is seen that the addition of crumb rubber reduces the empty ratio. It shows that the increase of crumb rubber content makes the air cavity contained in the mixture decrease because the crumb rubber will function as a binder that fills the cavity and helps bond between aggregate and asphalt. It can also increase the strength of the mixture.
3. From the research results, asphalt mixtures that have been affected by aging for 5 years can still be used for main roads with special requirements, such as playgrounds, jogging trails, or small roads

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