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Characteristics of AC-WC Asphalt Concrete Mixtures with Polystyrene Addition

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Abstract - The top layer of pavement that functions as a wear layer is called AC-WC/ Laston. Improving the quality of flexible pavement continues to be developed in order to create transportation support facilities that are safe, strong and durable, but still economical. The use of additives is one way out that can be done in order to get a high quality product. The purpose of this research is to identify the optimum asphalt content to be used in the manufacture of polystyrene asphalt mixtures and to determine the characteristics of asphalt mixtures using polystyrene additives. The method used was to add polystyrene in the form of styrofoam which had previously been dissolved using gasoline into hot asphalt with a percentage of polystyrene mixture of 3.0%, 3.5%, 4.0%, 4.5% and 5.0% of the optimum asphalt content used. Based on the results of testing specimens with additional polystyrene, VIM and VMA values increased at levels of 3.0% to levels of 4.5% exceeding the upper limit of VIM specifications, but still within specifications. The stability value increased along with the increase of polystyrene from 3.0% to 5.0%, where this value meets the specifications. The flow value increases from 3.0% to 3.45% levels exceeding the upper limit of the specification then decreases after 3.45% levels to 5.0% levels where the flow value meets specifications. The conclusion that can be drawn is that the addition of polystyrene mixture in AC-WC can increase the hardness level of the Laston mixture.

Keywords; AC-WC, Polystyrene, Additive, Laston.

I. Introduction

Layer asphalt concrete (Laston) is a surface layer on flexible road pavement, where this layer is a mixture of coarse aggregate, fine aggregate, cement, and asphalt using well-graded aggregates [1]. The aggregates are mixed until homogeneous, then spread and compacted in a hot state at a certain temperature. Flexible road pavement itself is the type of road pavement that is most often used in Indonesia because the price tends to be cheap, easy to work on, and suitable for the tropical environment, so the strength and durability of the road pavement must be able to withstand the traffic load that occurs on it.

Improving the quality of flexible pavement continues to be developed in order to create transportation support facilities that are safe, strong, durable, but still economical. The use of added materials is one way out that can be done in order to get a high quality product.

Polystyrene is a strong plastic made from ethylene and benzine that has been used for more than seven decades for various purposes. The resulting waste is difficult to destroy and can last for hundreds of years without decomposing naturally [2]. One of the polystyrene products is Styrofoam. It has thermoplastic properties, where this material will melt when it reaches a certain heat temperature, and will return to solid when it cools down. When mixed with gasoline, Styrofoam will melt and can function as an adhesive material.

The purpose of this research is to determine the optimum asphalt content value that will be used in the manufacture of polystyrene asphalt mixture. Another objective to be achieved is to determine the value of AC-WC characteristics using polystyrene mixture additives with variations of 3%, 3.5%, 4%, 4.5%, and 5% of the total weight of asphalt content.

II. Research Methodology

This research was conducted by adding styrofoam that had previously been dissolved using gasoline into hot asphalt with a percentage of styrofoam-gasoline mixture of 3.0%, 3.5%, 4.0%, 4.5%, 5.0% to the optimum asphalt content used. Styrofoam used is board type. 60/70 penetration asphalt was used.

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To determine the characteristics of coarse aggregate materials, gradation testing, aggregate specific gravity testing [3], angularity testing, material passing No. 200 sieve testing, aggregate oblong flat testing [4], abrasion testing with Los Angeles Machine [5], aggregate shape retention testing against sodium sulfate and magnesium sulfate solutions [6] and aggregate retention against asphalt were conducted.

Meanwhile, to determine the characteristics of fine aggregates, gradation testing, aggregate specific gravity testing [7], angularity testing, material testing of No. 200 sieve, Sand Equivalent and testing for clay lumps and breakable grains were carried out.

And to determine the characteristics of the binder (asphalt), asphalt specific gravity testing, asphalt penetration testing before TFOT, asphalt penetration testing after TFOT [8], asphalt softening point checking [9], weight loss testing, asphalt ductality testing before TFOT, asphalt ductality testing after TFOT [10] and solubility in trcholoreoethylene were carried out.

Samples were made based on the gradation obtained from the coarse and fine aggregate gradation tests. Sample preparation was done after knowing the combined aggregate composition and asphalt content of the initial mix. After the samples were made, marshall testing was carried out to determine the stability and flow values. Based on the test values, tables and graphs were made of the values of content weight, VIM (Voids In The Mixture), VMA (Voids In The Mineral Aggregate), VFB (Voids Filled With Bitumen), stability, flow and to determine the optimum asphalt content (KAO).

By using the optimum asphalt content of the test results, AC-WC samples were made with polystyrene additives. Before mixing in the asphalt, polystyrene (styrofoam) was first melted using gasoline.

Samples with added polystyrene were then tested for marshall based on SNI 06-2489-1991. Data processing was carried out based on predetermined data to determine the optimum mix content.

III. Results and Discussion

A. Examination of Material Characteristics

The test results of coarse aggregate characteristics and fine aggregate characteristics (stone ash) showed that all tests met the specification requirements and could be used as test specimen materials. Similarly, testing the characteristics of the asphalt binder showed that the asphalt meets the requirements and can be used as a binder for the test specimens.

The Asphalt Concrete - Wearing Course (AC-WC) design provides a combined aggregate proportion of; coarse aggregate (crushed stone 1-2) at 10%; coarse aggregate (crushed stone 0.5-1) at 30%, fine aggregate (stone ash) at 59%; and filler (cement) at 1%. The graph in Figure 1 shows that the mix composition meets the AC-WC mix specification.

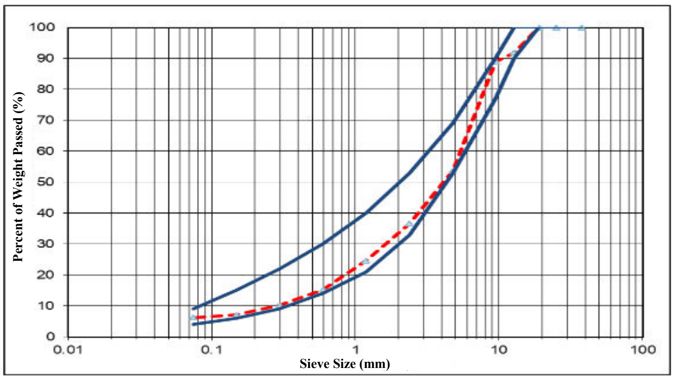

Figure 1. Combined Aggregate Gradation Chart of AC-WC Laston Mixture

To obtain the planned asphalt content of the AC-WC Laston mixture, the equation is used:

Pb = 0.035 (%CA) + 0.45 (%FA) + 0.18 (%FF) + K

Pb = 0.035 (46.33) + 0.45 (47.43) + 0.18 (6.23) + 1.0

Pb = 5.88% multiplied to 6.0%

Thus, the planned asphalt content of 5.0%, 5.5%, 6.0%, 6.5% and 7.0% was used. Furthermore, three test pieces were made for each different asphalt content, with

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a total mixture for one test piece/briquette of 1,200 grams.

Table 1. Aggregate Requirement for AC-WC Mixture

Material	As-phalt	Aggt 1/2	Aggt 0.5/1	Fly Ash	Cement	Total
Asphalt Content	(gr)	(gr)	(gr)	(gr)	(gr)	(gr)
5.0%	60	114.0	342.0	672.60	11.40	1200
5.5%	66	113.4	340.2	669.06	11.34	1200
6.0%	72	112.8	338.4	665.52	11.28	1200
6.5%	78	112.2	336.6	661.98	11.22	1200
7.0%	84	111.6	334.8	658.44	11.16	1200

B. Marshall Testing on AC-WC Mixture Test Objects

Marshall test results are the properties of asphalt mixtures, can be obtained after all material requirements, specific gravity and approximate plan asphalt content have been met. The weight content at 5.0% asphalt content was 2.230, then increased as the asphalt content increased. The VIM value at 5.0% asphalt content was 6.355, at 5,5% asphalt content, the VIM value was 4.986 then decreased as the asphalt content increased.The complete test results can be seen in Table 2.

Table 2. Marshall Testing of AC-WC Briquette Mix

Asphalt content	Weight Content	VIM	VMA	VFB	Stability	Flow	Ratio L.200 with EAC
5.0%	2.230	6.355	15.333	58.656	1937.54	2.77	1.39
5.5%	2.248	4.986	15.114	67.010	1844.30	3.23	1.24
6.0%	2.254	4.084	15.323	73.366	2008.85	3.34	1.11
6.5%	2.264	3.057	15.429	80.189	1743.95	3.53	1.01
7.0%	2.275	1.915	15.443	87.648	1575.06	3.73	0.93

After obtaining the Marshall test results, the Marshall value is depicted in a graph of the relationship between asphalt content and the calculated parameters.

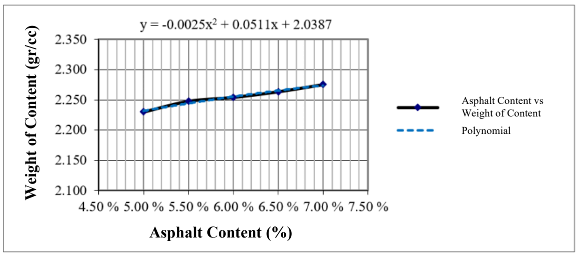

Figure 2. Relationship of Asphalt Content and Weight

Figure 2 shows that increasing the asphalt content will increase the weight of the mix until the voids in the mix are filled with asphalt. In other words, increasing the asphalt content will increase the weight of the mixture. This is shown in the graph at 5% to 7%.

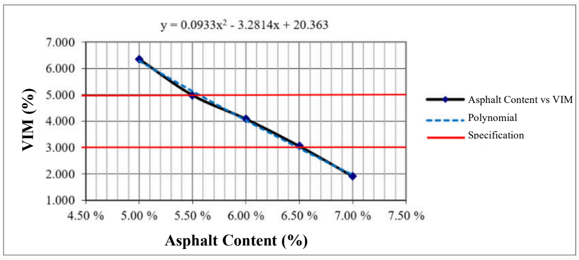

Figure 3. Relationship of Asphalt Content and VIM

Figure 3 shows that increasing the asphalt content causes the voids in the mixture to shrink. This is because asphalt is able to fill the existing cavities so that the cavities become smaller or tighter. In the 2018 General Specifications the required VIM value is 3% - 5% so that the asphalt content that meets is 5.5% - 6.5%. Figure 4 shows that the addition of asphalt content causes the VMA value to increase. In the 2018 Bina Marga General specification the minimum required VMA value is 15%.

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So there is no asphalt content that meets the specification.

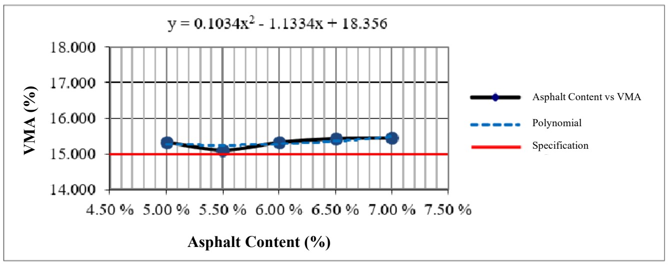


Figure 4. Relationship of Asphalt Content and VMA

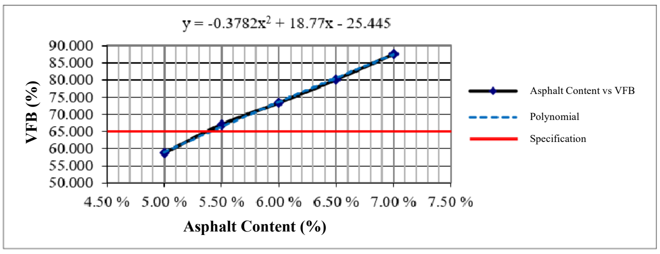


Figure 5. Relationship of Asphalt Content and VFB

Figure 5 shows that the addition of asphalt content causes the VFB value to increase. This is because the addition of asphalt content in the mixture causes the mixture cavities to be filled with more asphalt. According to the 2018 General Specifications, the required VFB value in the mixture is a minimum of 65%. The appropriate asphalt content is 5.5% - 7%.

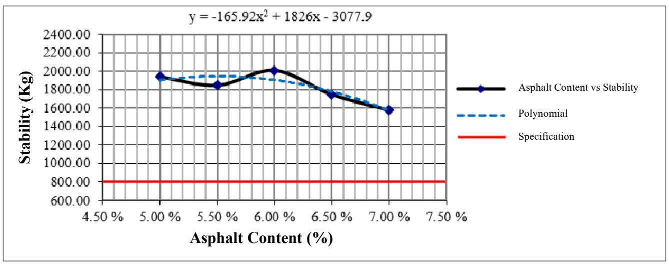
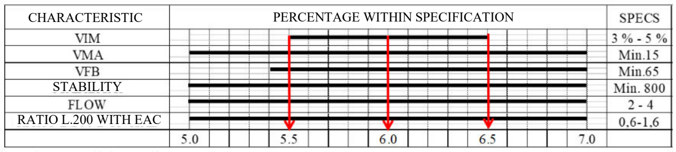


Figure 6. Relationship of Asphalt Content and Stability

Figure 6 shows that the continuous addition of asphalt content does not cause the stability value to increase because it is no longer effective. Too high asphalt content causes the asphalt to not cover the aggregate properly. Excessive asphalt is unable to be absorbed by the voids in the aggregate, which can cause bleeding. The 2018 General specification provides a minimum stability limit of 800 kg. From the graph all the asphalt content usage meets the requirement.

Tabel 3. Optimum Asphalt Content of Test Object



To find the optimum asphalt content, a graph was made as shown in Table 3 which shows the combination of VIM, VMA, VFB, stability, flow and L.200 ratio against the effective asphalt content. From the table, the optimum asphalt content value of 6% was obtained.

C. Preparation of Test Objects with Added Materials

After obtaining the KAO value of the mixture which is 6.0%, then test specimens were made with styrofoam-gasoline mixture additives using additional variations of 3.0%, 3.5%, 4.0%, 4.5%, 5.0% to the KAO weight of the mixture. The number of specimens made was three for each variation.

Tabel 4. Proportion of Test Objects with Added Polystyrene Material

Asphalt (gr)	Aggt ½ (gr)	Aggt. 0.5/1 (gr)	Fly Ash (gr)	Cement (gr)	Added Material Content	Additon Material (gr)
72.00	112.80	338.40	665.52	11.28	3.00%	2.16
72.00	112.80	338.40	665.52	11.28	3.50%	2.52
72.00	112.80	338.40	665.52	11.28	4.00%	2.88
72.00	112.80	338.40	665.52	11.28	4.50%	3.24
72.00	112.80	338.40	665.52	11.28	5.00%	3.60

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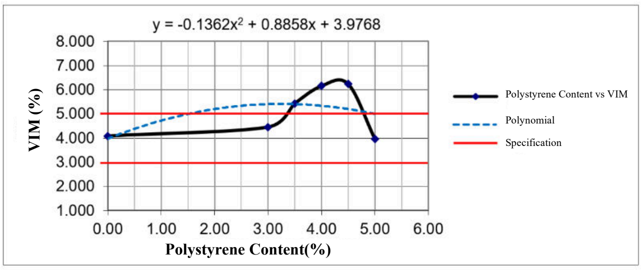

Figure 7. Relationship of Polystyrene Content and VIM

Marshall test results are the properties of the paved mixture and can be obtained after all material requirements, specific gravity and approximate plan asphalt content have been met. The marshall test results are then depicted in a graph of the relationship between asphalt content and the calculated parameters.

In mixtures with polystyrene additives there is a decrease in the weight content value up to a level of 4.1%, then increases thereafter. In mixtures with polystyrene additives, the VMA value increases up to 4.0%, then decreases thereafter. In mixtures with polystyrene additives there is a decrease in VFB value up to 4.0%, then decreases thereafter.

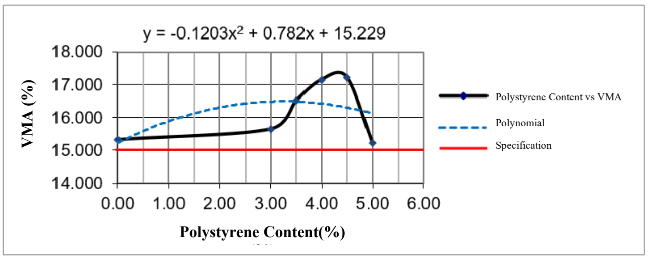

Figure 8. Relationship of Polystyrene Content and VMA

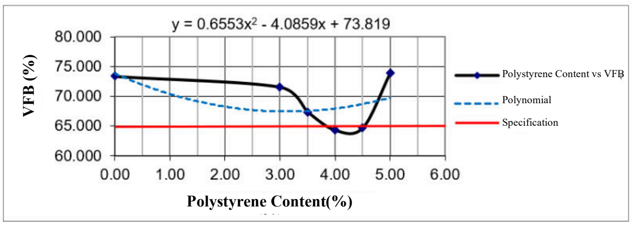

Figure 9. Relationship of Polystyrene Content and VFB

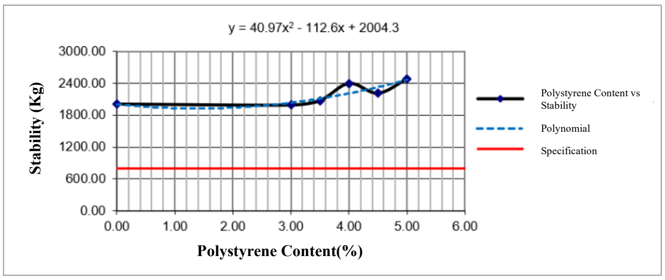

Figure 10. Relationship between Polystyrene Content and Stability

In mixtures with polystyrene additives, there is an increase in stability values along with the increase in polystyrene content. In mixtures with polystyrene additives there is an increase in flow value up to a level of 3.45%, then decreases thereafter. In mixtures with Styrofoam-gasoline additives, there is no increase or decrease in the ratio of combined aggregates passing sieve no. 200 to the effective asphalt content.

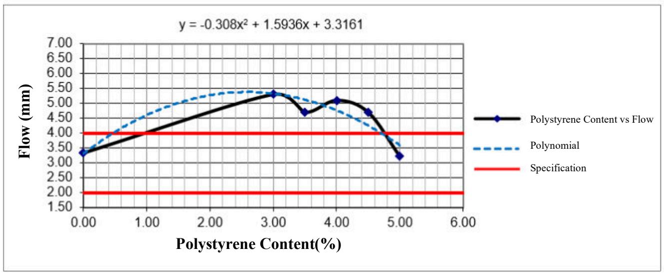

Figure 11. Relationship of Polystyrene Content and Flow

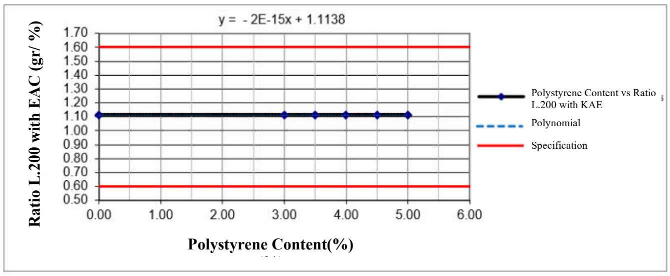

Figure 12. Relationship between Polystyrene Content and L.200 Ratio with Effective Asphalt Content

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IV. Conclusion

Based on the results obtained, the following conclusions can be drawn:

1. The optimum asphalt content value was obtained at 6.0% with a mixture composition of 10% crushed stone 1-2, 30% crushed stone 0.5-1, 59% stone ash and 1% cement.
2. The value of AC-WC characteristics in the addition of polystyrene for all variations, the addition has an increasing stability value, the value of content weight and VFB has decreased then increased again, the value of VIM, VMA and flow has increased then decreased again, the value of the ratio of L.200 to the effective asphalt content has not changed.

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