PERFORMANCE OF AC-BC MIXTURE WITH ACRYLONITRILE BUTADIENE STYRENE (ABS) PLASTIC ADDITIONAL ASSESSMENT FROM MARSHALL'S PARAMETERS

Rizal Prasetyo[1], Boedi Rahardjo[2] and Pranoto [3]

[1]*State University of Malang, email : rizalprasetyo99@gmail.com*
[2]*State University of Malang, email: boedi.rahardjo.ft@um.ac.id*
[3]*State University of Malang, email: pranoto.ft@um.ac.id*

Abstract: The problem that is often encountered in Indonesia is road damage, especially on roads with heavy traffic volume. On the other hand, Indonesia is a country that is included in the largest producer of plastic waste in the world. Efforts are needed to reduce plastic waste and to improve the quality and performance of the pavement layer, then asphalt modification with plastic added materials can be a solution. Therefore, this research uses ABS plastic waste added material to reduce waste. The purpose of this research is to describe the characteristics of the constituent materials in the AC-BC mixture with the addition of ABS, describe the effect of pavement on the AC-BC mixture using ABS added material in terms of Marshall parameters, describe the performance Residual Strength Index (IKS) on AC-BC asphalt mixture using ABS added material. The research design includes the stages of material preparation in the form of aggregate, asphalt, filler, ABS added material. Then make the test object using asphalt content of 5%, 5.5%, 6%, 6.5%,7%, and the Marshall test is carried out to obtain the Optimum Asphalt Content (KAO). Second, make KAO test objects with ABS at levels of 0%, 1.5%, 3%, 4.5%, and 6% by wet method and tested by Marshall to get KABSO (Optimum Acrylonitrile Butadiene Styrene Levels). Then, make the KAO test object with the addition of ABS to get the IKS value by immersing it for 30 minutes and 24 hours. The results obtained made KAO specimens with ABS at levels of 0%, 1.5%, 3%, 4.5%, and 6% by wet method and tested by Marshall to get KABSO (Optimum Acrylonitrile Butadiene Styrene Levels). Then, make the KAO test object with the addition of ABS to get the IKS value by immersing it for 30 minutes and 24 hours. The results obtained made KAO specimens with ABS at levels of 0%, 1.5%, 3%, 4.5%, and 6% by wet method and tested by Marshall to get KABSO (Optimum Acrylonitrile Butadiene Styrene Levels). Then, make the KAO test object with the addition of ABS to get the IKS value by immersing it for 30 minutes and 24 hours. The results obtainedthe constituent materials of AC-BC have met the 2018 Bina Marga specifications and obtained an KAO of 6.5%.The addition of ABS in the asphalt makes the mixture harder, which is indicated by a decrease in the value of penetration and ductility and an increase in the softening point of the asphalt. In addition, the addition of ABS in asphalt makes the flash point value and asphalt burn decrease.Marshall AC-BC performance with ABS obtained stability values, MQ, and VFA increased, then flow, VIM, and VMA values decreased. The optimum ABS content was obtained at 3%, the IKS value in the AC-BC mixture with the addition of ABS obtained the highest IKS value at the addition of 4.5% ABS.

Keywords: *acrylonitrile butadiene styrene*, ac-bc, marshall parameters

1. INTRODUCTION

One of the problems that are often encountered in Indonesia is road damage, especially on roads that have the capacity to accommodate busy traffic. According to Yunardhi (2018) road infrastructure that is burdened with the capacity to accommodate busy and repetitive traffic, will experience a depreciating value (quality) of the road. As an indicator, it can be seen from the structure and function of the top layer of the road that has been damaged. This is reinforced by research conducted by Putra (2019) said that according to the nature, volume and function of traffic, optimal road construction must be planned to meet technical requirements, so that road construction can benefit the development of the surrounding area. On the other hand, Indonesia is one of the largest producers of plastic waste in the world. Indonesia is able to produce up to 64 million tons of plastic waste per year, of which 3.2 million tons are dumped into the sea. Around 85,000 tons of plastic bag waste or as much as 10 billion pieces per year are dumped into the environment (Priliantini et al, 2020).

In an effort to minimize environmental pollution by plastic waste as well as to improve the quality and performance of the pavement layer, modifying asphalt with plastic added materials can be a solution. Additional materials in the asphalt mixture can use plastic waste because according to Mujiarto (2005) plastic has good characteristics such as thermal stability up to 250˚C, composition above 250˚C, has a softening point of 120-160˚C, and has good binding ability. ABS is classified as a type of thermoplastic engineering plastic that contains three forming monomers. Acrylonitrile is heat stable and chemical resistant. Butadiene improves toughness and impact resistance, while styrene is malleable and ensures rigidity.

Research conducted by Hamedi et al. (2019) showed that the use of ABS plastic as an additive in asphalt modification can strengthen the nonpolar nature of the binder which can help form a stronger nonpolar bond between asphalt and aggregate, especially in wet conditions. Modification of asphalt binder with ABS polymer increases the components in asphalt binder modification. The good performance improvement of the addition of ABS plastic to the asphalt mixture was proven in a research conducted by Sekar et al. (2015) showed that the basic empirical tests namely softening point, ductility and penetration point were within the tolerance limits for ABS plastic used in flexible pavements. These results indicate that ABS plastic has a higher temperature susceptibility and lower deformation due to cracking. Judging from the thermal research that ABS plastic has better temperature resistance properties with increased bonding properties. ABS plastic exhibits lower thermal deformation. This will help reduce rutting and cracks in the road.

Pavement reinforcement is engineered to take advantage of the high stability of the addition of ABS plastic and the asphalt's ability to withstand structural stresses on the road. Addition of ABS polymer. The mixture of asphalt concrete with a surface wear layer is able to provide a function related to the Marshall parameter and is continued with the evaluation of the Residual Strength Index (IKS) value obtained from the Marshall Immersion test (Marshall Immersion). The Residual Strength Index (IKS) test aims to determine the strength of asphalt concrete that is damaged due to water immersion which is expressed as a stability value (Zurni, 2015).

2. METHOD

The method used in this research uses the method experimental research that is quantitative in the form of numbers and interval data from research results. The research was conducted at the Road Pavement Laboratory of Building D19, Department of Civil Engineering, Faculty of Engineering, State University of Malang. The technical specifications used are guided by the General Specifications of Highways for Road and Bridge Construction Works in 2018. This research was carried out in stages which were divided into three stages of research, namely:

a. Preparation phase

1. Prepare materials needed in researching the form of aggregates, asphalt, added materials in the form of plastic waste ABS.
2. Prepare the necessary equipment for the manufacture and testing of test objects.

b. Implementation Stage

1. selection and testing of aggregates, asphalt and added materials in the form of plastic waste ABS.
2. Inspection and testing of research materials used in the form of aggregates, fillers, hard asphalt 60/70 penetration, as well as added materials in the form of waste ABS plastic.
3. Manufacture of test objects to obtain the value of KAO (Optimum Asphalt Content).
4. Making KAO test objects with the addition of waste ABS plastic.
5. Manufacture of KAO specimens with each ABS content for IKS testing.

c. Completion Stage

1. Performing descriptive data analysis obtained from the test results.
2. Processing research data in the form of graphs and drawing conclusions from research results

3. RESULT

The results of the examination of the research materials show that the research materials which include aggregate, asphalt, and filler have met the 2018 Highways specifications for the AC-BC mixture. The results of the examination of research materials are shown in the following table.

Table 1. Coarse Aggregate and Fine Aggregate Test Results

No.	Test Type	Testing Method	Specification Min	Specification Max	Test result
1.	Coarse Aggregate Density				
	BJ Bulk (gr/cm3)	SNI 1969:2008	2.5	-	2.71
	Pseudo BJ (gr/cm3)		-	-	2.88
	BJ SSD (gr/cm3)		-	-	2.81
	Absorption (%)		-	3	2.21
2.	Fine Aggregate Density				
	BJ Bulk (gr/cm3)	SNI 1970:2008	2.5	-	2.58
	Pseudo BJ (gr/cm3)		-	-	2.58
	BJ SSD (gr/cm3)		-	-	2.50
	Absorption (%)		-	3	2.8
3.	Los Angeles Abrasion Testing (%)	SNI 2417:2008	-	40	12.47

Table 2. Test Results for Portland Cement Filler Density (PC)

Sample Number		Test Object Results I	II	III	Average
Test object weight (grams)	B	63.6	63.8	64	
Initial Volume (ml)	V1	1	1	1	
Final Volume (ml)	V2	21.6	21.3	21.6	
Cement specific gravity (gr/ml)	$\frac{B}{(V_2 - V_1)} \times d$	3.09	3.14	3.11	3.11 gr/cm3

Table 3. Asphalt Test Results and Asphalt Testing with the addition of ABS

Test Type	Testing Method	Specification	Test result Percentage Level of Acrylonitrile Butadiene Styrene(ABS)				
			0%	1.5%	3%	4.5%	6%
Specific Gravity (gr/cm3)	SNI 2441:2011	1.0 gr/cm3	1.024	1.024	1.030	1.037	1.064
Penetration (dmm)	SNI 2456:2011	Reported	64.40	61.07	39.93	38.33	32.13
Softening Point (ºC)	SNI 2434:2011	Reported	48.25	50.35	51.85	53.25	54.95
Flash Point (ºC)	SNI 2433:2011	232°C	330	313	308	309	305
Fire Point (ºC)	SNI 2433:2011	232°C	338	325	323	321	317
Ductility(cm)	SNI 2432:2011	Reported	146	63.33	56.33	44.33	35.67
Weight of Loss (%)	SNI 2441:1991	0.8%	0.00006	0.00017	0.00015	0.00021	0.00015

After the entire research material meets the required specifications, then the test object is made for determining the Optimum asphalt content (KAO) where the test object is planned for heavy traffic with the number of collisions used 2x75. Marshall test results for KAO test objects are presented in table 4.

Table 4. Interaction Diagram for determining KAO (Optimum Asphalt Content)

MARSHALL PARAMETERS	SPECIFICATION STANDARDS		TEST RESULT PERCENTAGE OF ASPHALT LEVELS (%)				
	Min	Max	5	5.5	6	6.5	7
Stability (kg)	800	-	993.10	1050,30	969.78	966.06	815.85
Flow(mm)	2	4	2.72	3.01	3.29	3.36	3.61
MQ(kg/mm)	250	350	365.07	352.72	295.50	288.93	226.08
VIM (%)	3	5	6.93	5.55	5.23	4.21	3.86
VMA (%)	14	-	16.87	16.72	17.52	17.69	18.45
VFA (%)	65	-	61.17	67.23	70.93	77.80	79.39

The interaction diagram for determining KAO obtained an asphalt content of 6.5% which met all specifications, starting from stability, flow, MQ, VIM, VMA and VFA. This KAO value is used to make test objects with the addition of added materials *Acrylonitrile Butadiene Styrene* (ABS)

Table 5. Level determination Interaction Diagram*Acrylonitrile Butadiene Styrene*(ABS)Optimum (KABSO)

MARSHALL PARAMETERS	SPECIFICATION STANDARDS		TEST RESULT PERCENTAGE OF ABS LEVELS (%)				
	Min	Max	0	1.5	3	4.5	6
Stability (kg)	1000	-	966.06	1134.73	1167.96	1177.32	1146.25
Flow(mm)	2	4	3.36	3.88	3.86	3.83	4.24
MQ(kg/mm)	200	350	288.93	292.71	305.66	307.56	271.39
VIM (%)	3	5	4.21	4.05	3.66	2.81	2.41
VMA (%)	15	-	17.69	17.56	17.23	16.50	16,16

VFA (%)	65	-	77.80	77.22	79.09	83.24	85.17

The interaction diagram for the determination of KABSO shows that the addition of 1.5% and 3% ABS content meets the specifications covering stability, flow, MQ, VIM, VMA and VFA. To determine the KABSO value, it is taken from the total value of the percentage of ABS plastic content that meets the requirements and then divided by two to obtain a KABSO value of 2.25%.

Table 6. IKS Test Result Recap *Acrylonitrile Butadiene Styrene* (ABS)

DESCRIPTION	ABS Grade (%)	Asphalt Content (%)	Stability		IKS
			S1	S2	$= \frac{S2}{S1} \times 100$
KABS	0	6.5	966.06	896.38	92.79
KABS	1.5	6.5	1134.73	1072.36	94.5
KABS	3	6.5	1167.96	1105.64	94.66
KABS	4.5	6.5	1177.32	1116.03	94.79
KABS	6	6.5	1146.25	1079.16	94.15

Value of Residual Strength Index (IKS) of AC-BC asphalt mixture with added materialsABSThe highest IKS value was found in the addition of ABS content of 4.5% with an IKS value of 94.79%.

4. DISCUSSION

The interaction diagram in table 4. for the determination of KAO obtained an asphalt_content of 6.5%. This KAO value is used to make test objects with the addition of ABS plastic added.

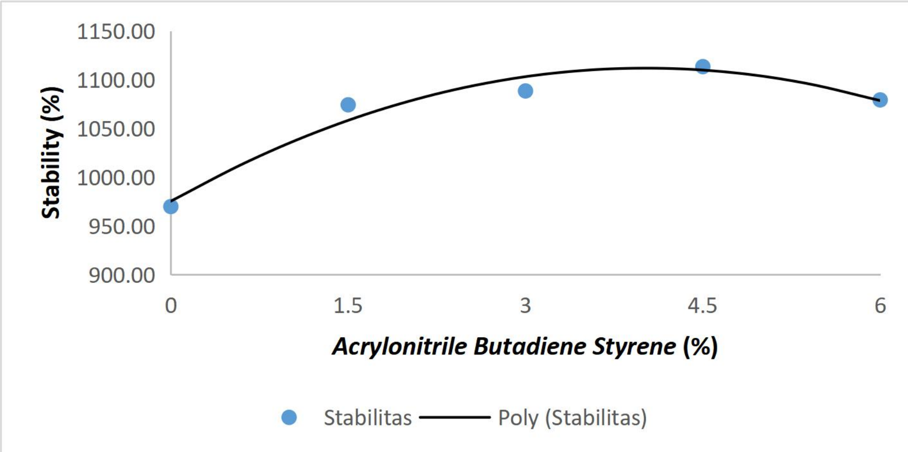

Figure 1. Connection between ABS content (%) and Stability (kg)

Figure 1 shows that the increase in the ABS plastic content can affect the stability value of the asphalt mixture, namely increasing the stability value of the asphalt mixture, so as to improve the quality of the asphalt concrete mixture. Similar research was conducted by Sekar (2015) where the percentage of ABS levels in the research used levels of 0%, 5%, and 7%. The resulting stability value at the addition of 0% ABS content of 1100 kg. Then with the addition of 5% ABS content, the stability value obtained was 1800 kg, and then the addition of 7% ABS content decreased the stability value to 1700 kg. The minimum stability value thatrequiredfor the research is a minimum of 1000 kg. So that the stability value obtained for each ABS grade has met the specifications set by Bina Marga 2018.

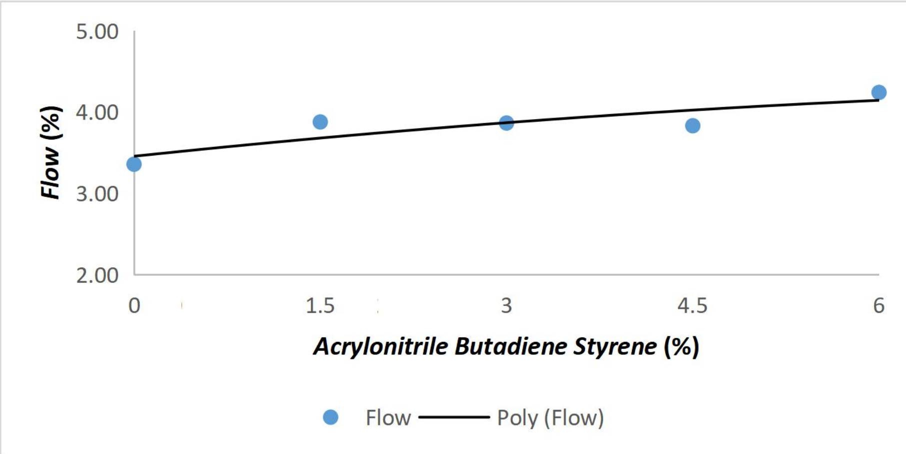

Figure 2. Connection between ABS content (%) and flow (mm)

Figure 2 shows that as the ABS content increases in the laston mixture, it can affect the flow value, namely the flow value increases. The flow value will increase along with the increase in ABS content in the asphalt-concrete mixture. A high flow value in LDPE indicates that the mixture is more flexible and less prone to cracking. The results of this research are in line with research conducted by Sekar (2015) which explains that the flow value will decrease as the percentage of ABS content is added to the mixture. In the mixture with the addition of ABS content of 0%, 5%, and 7%, the flow values were 3.3 mm, 3.4 mm, and 3.5 mm, respectively.

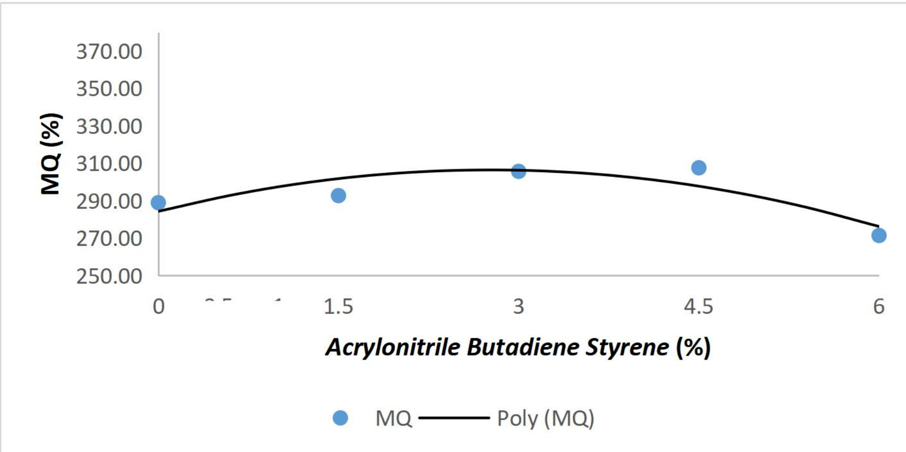

Figure 3. Connection between ABS content (%) and MQ (kg/mm)

Figure 3 shows that as the ABS content increases, it can affect the MQ value in the asphalt mixture. The addition of ABS made the MQ value increase, but then the MQ value decreased with the addition of 6% ABS. The addition of ABS plastic obtained high stability, followed by a high flow value, so that the properties of the mixture were more plastic.

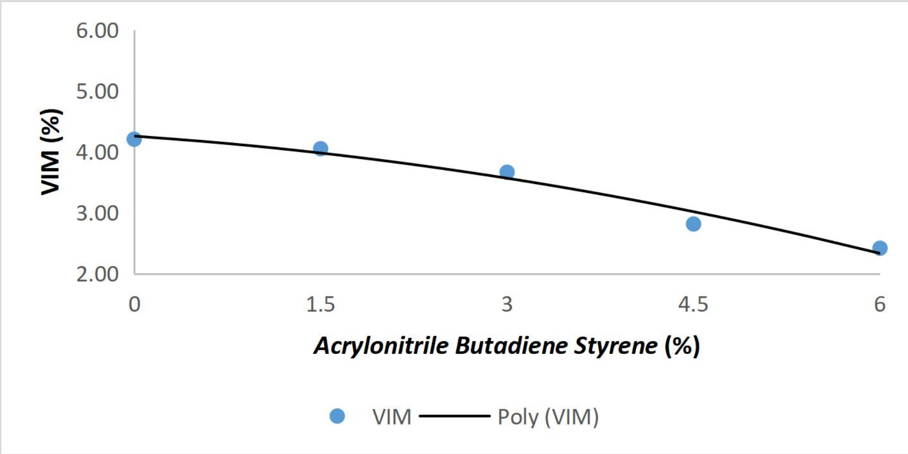

Figure 4. Connection between ABS content (%) and VIM (%)

Figure 4 shows the VIM value with the addition of ABS decreasing with the addition of ABS content. The highest VIM value is found in the asphalt mixture without ABS added and the lowest is found in the addition of 6% ABS content. ABS plastic has a high melting point, which makes asphalt when mixed with ABS plastic becomes more viscous when mixed at a certain temperature, so that the mixed asphalt and ABS are difficult to enter the cavity in the asphalt-concrete mixture. A similar research was also conducted by Singh (2019) who explained that the VIM value with the addition of 0% ABS content had a VIM value of 3.81% and with the addition of 4% ABS content the VIM value increased to 3.89%.

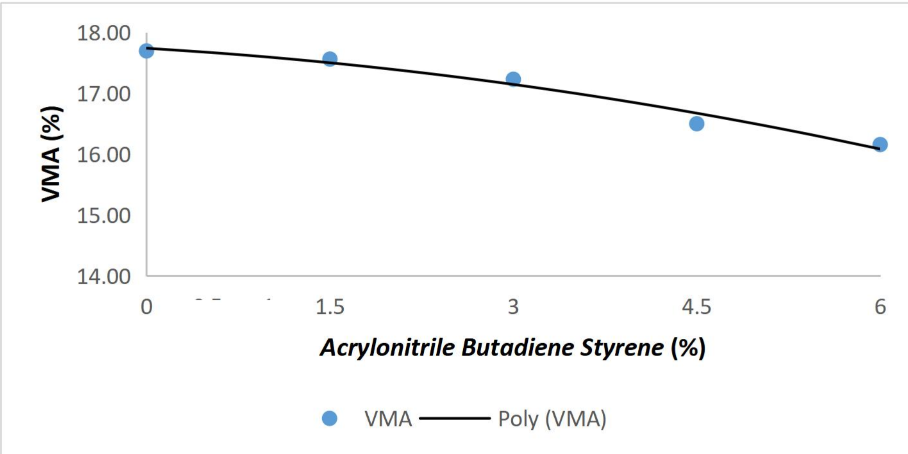

Figure 5. Connection between ABS content (%) and VMA (%)

Figure 5 shows that asphalt and ABS plastic that have been mixed will more easily cover the aggregate in the asphalt-concrete mixture. ABS plastic has a high melting point which makes the mixture more viscous and more difficult to coat the aggregate in the asphalt concrete mix. This has an effect on the VMA value which has decreased. VMA value with the addition of ABS decreased with the addition of ABS content. The highest VMA value is found in the asphalt mixture without ABS added and the lowest is in the addition of 6% ABS content.

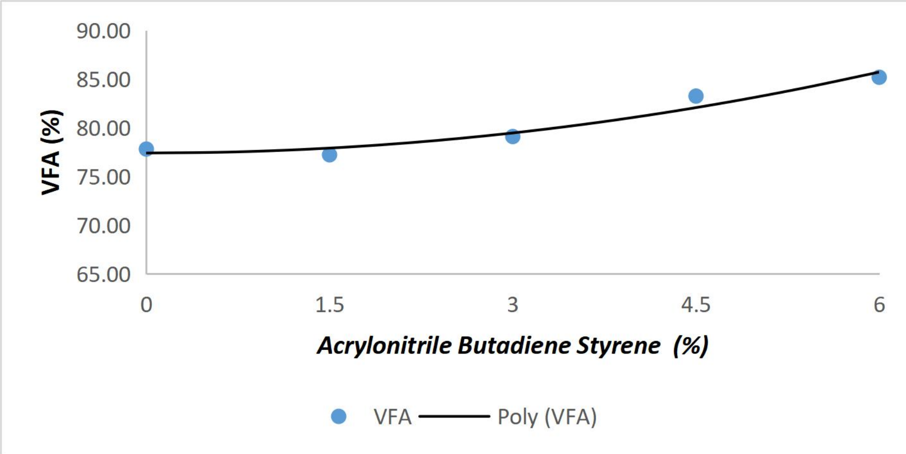

Figure 6. Connection between ABS content (%) and VFA (%)

Figure 6 showsthat the small voids in the mixture in ABS plastic make the voids filled with asphalt more and more, so that the density of the mixture increases. Asphalt when mixed with ABS plastic will be more viscous and create a large cavity in the mixture and result in a small cavity filled with asphalt, so that the density of the mixture decreases. In line with the research conducted by Singh (2020) showed that there was a decrease in the VFA value of the test object without the addition of ABS with the test object after the addition of ABS content to the test object. Where the VFA value on the test object without the addition of ABS has a value of 74.21% and then the VFA value decreases with the addition of 4% ABS content with a VFA value of 73.82%.

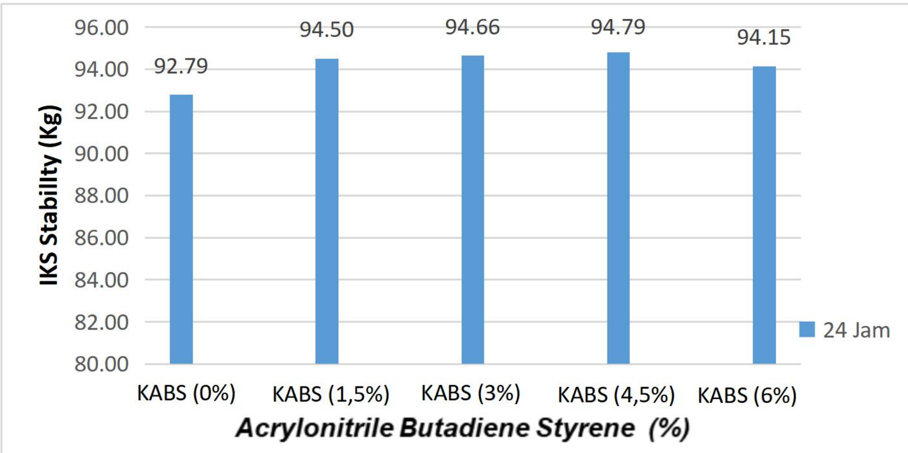

Figure 7. Comparison chart of IKS value usage ABS as Additive

Figure 7 shows that the IKS values with ABS plastic added have all met the specifications with the highest IKS value found in the addition of 4% ABS content of 94.79 kg. The results obtained that the test object with the addition of ABS increased the IKS value at the addition of 1.5% ABS content to 4.5% which then decreased the IKS value at the addition of 6% ABS content. This can happen because the stability value at 30 minutes and 24 hours immersion has increased until it finally decreases the stability value at 6% level. This is reinforced by research conducted by Sekar (2015) with the results of the research conducted, namely the stability value increased at the addition of 0% to 5% ABS levels, then the stability value decreased at the addition of 7% ABS levels.

5. CONCLUSION

The mixed constituent materials have met the 2018 Bina Marga specification standards which refer to the SNI provisions which include coarse aggregate, fine aggregate, filler, and asphalt which are suitable to be used as mixture constituents. From all Marshall parameters on test specimens with the addition of ABS, the optimum levels and meet all specifications are found in the addition of 1.5% and 3% ABS levels so that the asphalt content value with the addition of the optimum ABS plastic is 2.25%.

Value of Residual Strength Index (IKS) of AC-BC asphalt mixture with added materialsABSThe highest IKS value was found in the addition of ABS content of 4.5% with an IKS value of 94.79%. The results obtained meet the minimum specifications of 90% for the modified AC-BC mixture, but the addition of 4.5% ABS content does not meet the standard on the Marshall parameter. The AC-BC mixture that uses ABS added material has better durability and resistance to water and temperature than the AC-BC asphalt mixture with KAO.

6. REFERENCES

Hamedi, G. H., Ranjbar Pirbasti, Z., & Esmaeili, N. 2019. Laboratory investigation of the effect of ABS polymer on moisture susceptibility of asphalt mixtures. *Australian Journal of Civil Engineering*, *17*(2), 96–109. https://doi.org/10.1080/14488353.2019.1643639

Mujiarto, I. 2005. Sifat dan Karakteristik Material Plastik dan Bahan Aditif. *Traksi*, *3*(2), 65–74.

Priliantini, A., Krisyanti, K., & Situmeang, I. V. 2020. Pengaruh Kampanye #PantangPlastik terhadap Sikap Ramah Lingkungan (Survei pada Pengikut Instagram @GreenpeaceID)
DOI: 10.31504/komunika.v9i1.2387. *Jurnal Komunika : Jurnal Komunikasi, Media Dan Informatika*, *9*(1), 40. https://doi.org/10.31504/komunika.v9i1.2387

Putra, F. E. 2019. Analisa Kerusakan Jalan Dengan Metode Lhr Bina Marga (Studi Kasus Ruas Jalan Amd Projakal Kariangau, Kota Balikpapan). *Jurnal Tugas Akhir Teknik Sipil*, *Vol 3 No 1*.

Sekar, Ramalinga Chandra, A., Mahendran, M., Vasudevan, R., & Velkennedy, R. 2015. Polymer modified bitumen prepared using ABS polymercharacterization and application in flexible pavement. *ARPN Journal of Engineering and Applied Sciences*, *10*(8), 3786–3792.

Singh, P. K., Suman, S. K., & Kumar, M. 2020. Influence of Recycled Acrylonitrile Butadiene Styrene (ABS) on the Physical, Rheological and Mechanical Properties of Bitumen Binder. *Transportation Research Procedia*, *48*(2019), 3668–3677. https://doi.org/10.1016/j.trpro.2020.08.081

Yunardhi, H. 2018. Analisa Kerusakan Jalan Dengan Metode Pci Dan Alternatif Penyelesaiannya (Studi Kasus : Ruas Jalan D.I. Panjaitan). *Jurnal Teknologi Sipil*, *2*(2), 38–47.

Zurni, Rahmi.2015. Pengaruh Penggunaan Polimer Elvaloy Terhadap Nilai Indek Kekuatan Sisa Pada Campuran Material Perkerasan Daur Ulang. Jurnal Itenas

Rekayasa. No.1. Institut Teknologi Nasional.