JURNAL IPTEK

MEDIA KOMUNIKASI TEKNOLOGI

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THE EFFECT OF USING STYROFOAM AS ADDITIONAL MATERIAL FOR ASPHALT CONCRETE LAYER (LASTON) – WC WITH BNA BLEND

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ARTICLE INFORMATION

Jurnal IPTEK – Volume 26 No. 1, May 2022

Page:
15 – 22
Published Date :
31 May 2022

DOI:
10.31284/j.iptek.2022.v26i1.2433

ABSTRACT

Asphalt concrete layer (laston) has a high degree of flexibility so that placing it directly on top of layers such as AC-WC (Asphalt Concrete – Wearing Course) makes this layer vulnerable to damage due to high temperatures and heavy traffic loads. The type of damage that often occurs in the laston is the release of granules and cracks. Styrofoam is a type of plastic polymer that is thermoplastic when heated it becomes soft and hardens when cold. When mixed with gasoline, styrofoam will soften and can function as an adhesive. This study was to determine the value of Marshall characteristics in the addition of styrofoam into the asphalt.variations used for styrofoam content are 1%, 1.5%, 2% with asphalt content of 4.5%, 5.0%, 5.5%, 6.0%. The results showed that the optimum asphalt value was obtained at 6% asphalt content. And the mixture that meets the requirements is the addition of 1% styrofoam. Higher content of styrofoam will reduce the value of the melt (flow) and will reduce the value of Marshall stability.

Keywords: *Styrofoam, Asphalt Additive, Marshall Stability*

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ABSTRAK

Lapisan aspal beton (laston) memiliki tingkat fleksibilitas yang tinggi sehingga penempatan langsung di atas lapisan seperti lapis aus (*Asphalt Concrete – Wearing Course*) AC-WC membuat lapisan ini rentan terhadap kerusakan akibat temperatur yang tinggi dan beban lalu lintas berat. Jenis kerusakan yang sering terjadi pada laston adalah pelepasan butiran dan retak. Styrofoam adalah salah satu jenis polimer plastik yang bersifat termoplastik apabila dipanaskan akan menjadi lunak dan mengeras ketika dingin. Penelitian ini untuk mengetahui nilai karateristik Marshall dengan variasi penambahan styrofoam ke dalam aspal. variasi yang digunakan untuk kadar styrofoam adalah 1%, 1,5%, 2% dengan kadar aspal 4,5%, 5,0%, 5,5%, 6,0%. Hasil penelitian menunjukkan nilai optimum aspal di dapatkan pada kadar aspal 6%. Dan campuran yang memenuhi syarat adalah dengan penambahan styrofoam sebanyak 1%. Kadar styrofoam yang terlalu tinggi akan menurunkan nilai kelelehan (*flow*) dan akan menurunkan nilai stabilitas Marshall.

Kata Kunci: Styrofoam, Bahan Tambahan Aspal, Stabilitas Marshall

INTRODUCTION

Roads are infrastructure that support the needs in people's daily activities. In general, road damage is a complex problem and has serious implications for the future. Some of the causes that cause road damage are poor drainage channels so that causes puddles of water on the road surface, excessive traffic loads accompanied by very dense vehicle intensity which further shortening the life of the road from the predetermined design life. The availability of sufficient hard coating materials that meet specifications is absolutely required in the development of sustainable road infrastructure.

This condition makes it difficult to procure materials that meet specifications, even though many local materials are becoming known but have not been used to their full potential. Modifying asphalt is one way to improve asphalt quality by adding material such as styrofoam, with aim of improving the physical and mechanical properties of asphalt.

Styrofoam is a synthetic material, known as cork. Styrofoam is usually used to protect electronic materials. After unused, Styrofoam is simply thrown in the trash. The accumulation of styrofoam waste in the final disposal site (TPA) will cause new problems, because this waste is difficult to recycle. This fact makes it crucial to manage, safely dispose, utilize and recycle this tyoe of waste. One excellent domain for the utilization of (EPS) is as a modifier in bituminous materials [1]. Styrofoam is a type of plastic polymer (also known as expanded polystyrenen (EPS)) that is thermoplastic when heated it becomes soft and hardens when cold. When mixed with gasoline, Styrofoam will soften and can function as an adhesive. In addition, it is resistant to acids, bases, and other corrosive properties such as salt [2] and is easily soluble in aromatic hydrocarbons [3].

Seeing that styrofoam has several advantages, one of which is easily soluble in aromatic hydrocarbons, then it is necessary to conduct laboratory tests on the effect of using styrofoam as an additive to mix asphalt concrete layer (laston) - WC pavement with asphalt BNA blend. This study aims to obtain the optimum styrofoam content between the closer ranges of 1%, 1.5%, 2% based on previous studies [4]–[6]. The parameters that can be determined from this test are stability, flow, Marshall Quotient (MQ), Void in Mix (VIM), Void in Mineral Aggregate (VMA), Void Filled with Asphalt (VFB).

LITERATURE REVIEW

Asphalt Concrete – Wearing Course

Asphalt Concrete – Wearing Course (AC – WC) is a layer of pavement that is in direct contact with vehicle tires. It has characteristics such as water-resistant, weather-resistant, and has the required roughness with a minimum thickness of 4 cm. These layers function to receive traffic loads and distribute them to the layers below in the form of vehicle loads (vertical force), brake forces (horizontal force) and vehicle wheel blows (vibration), and the lower the depth, it gets the bigger load distribution. The arrangement of layers of flexible pavement construction consists of: surface course, base course, subbase course, and subgrade [7]. AC – WC is included in flexible pavement that consist of coarse aggregate, fine aggregate, filler and asphalt as a binder [8].

Filler

Filler is material that passes sieve no. 200 (0.075 mm) and includes hydrated lime, fly ash, portland cement and rock ash. Filler can serve to reduce the number of air voids in the mixture, however the amount of filler must be limited to a favorable limit. Too high a filler content tends to cause the mixture to become brittle and as a result it will crack easily due to traffic loads [9]–[11]. On the other hand, too low filler content causes the mixture to become mushy at high temperatures [12].

Styrofoam

The use of styrofoam waste as an alternative material for asphalt pavement reinforcement is a brilliant idea, because it can reduce the amount of waste that must be disposed of into the environment, considering that the amount of styrofoam waste always increases from year to year. Some researches showed that the higher the percentage of styrofoam in the asphalt, the better the performance of the AC-WC pavement mixture [13] and there is a change in the value of the Marshall characteristics in the mixture of asphalt and styrofoam [14], [15]. The percent reduction in ductility and penetration with the addition of Styrofoam to the asphalt binder was found to be significant for unaged and aged samples at the 5 percent significance level as shown in Figure 1 [1].

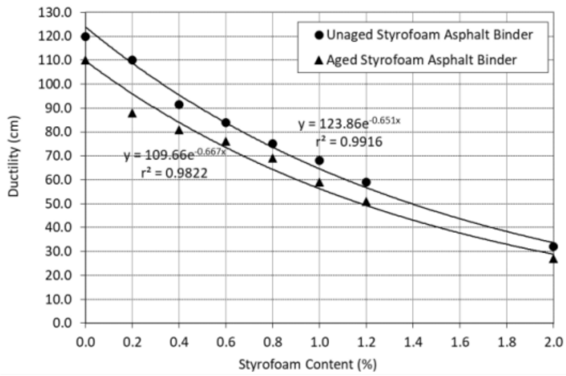


Figure 1. Ductility versus Styrofoam to asphalt percentage

If granular Styrofoam or expanded polystyrene is formed, the unit weight becomes very small, which is only in the range of 13 - 16 kg/m3. Styrofoam is a material that is good in terms of both mechanical and temperature, but is somewhat brittle and soft at temperatures below 100°C [16].

Buton Natural Asphalt

BNA (Buton Natural Asphalt) is the result of asbuton purification with bitumen content of 55-60% which allows positive things from asbuton to be optimized. Bitumen is widely known for its superior quality and instant properties which are able to form composites with oil asphalt, resulting in higher quality bitumen. BNA bitumen has a high softening point and adhesion, which will increase the dynamic stability of the mixture and reduce the possibility of reveling. The hydrophobic filler content in an optimal amount and evenly distributed in the BNA will form a strong and more water-resistant asphalt mastic which is expected to increase the resistance of the mixture to the negative effects of water. With these characteristics, BNA is very suitable to be used as an oil asphalt modifier. With a relatively low mineral content, BNA can be used up to 25% in asphalt mixtures, thus enabling higher absorption of asbutone [17].

RESEARCH METHODOLOGY

The flowchart methodology of this research is available in the Figure 2.

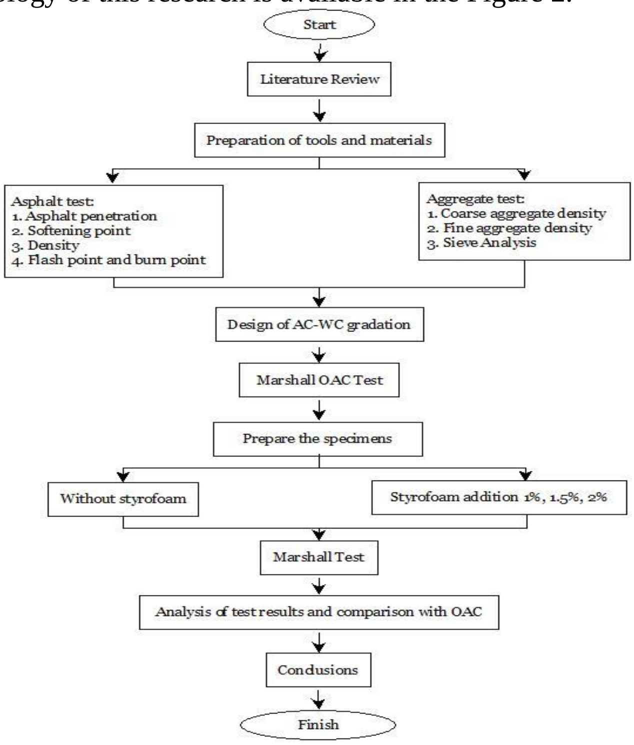
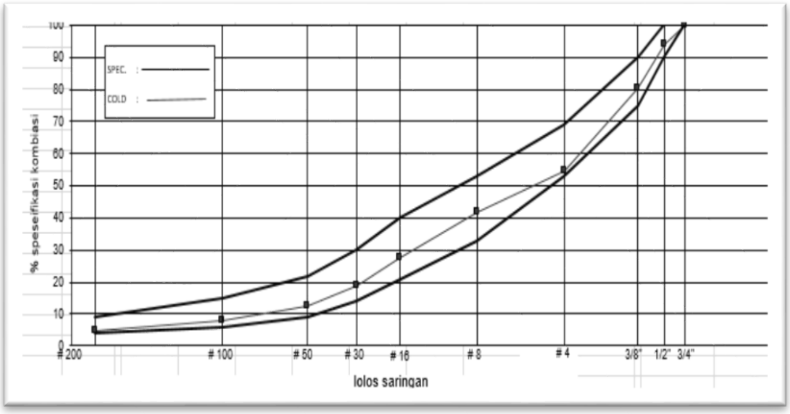


Figure 2 . Flow Chart of Methodology Research

The asphalt mix design method used is hot mix design, which is a mixture consisting of aggregate components where the mixing method is through a heating process. Meanwhile, to determine the aggregate composition using the trial and error method. If it meets the specifications, then an aggregate graph and a specification graph are made as shown in Figure 3. In this study used variations in asphalt content of 4.5%, 5.0%, 5.5%, 6.0% which will be made as many as 3 test samples of each asphalt content by Marshall test. Furthermore, the preparation of specimens with styrofoam additives to be tested with the Marshall test.



: Aggregate Combination
: Specification Limit

Figure 3. Graph of Aggregate Gradation Planning Results

These results are used to calculate the design asphalt content using the formula from Bina Marga as shown below.

$$Pb = 0{,}035\ (\%CA) + 0{,}045\ (\%FA) + 0{,}18(\%FF) + K$$

Where:

Pb = Initial design asphalt content (% of mix weight)

CA = Coarse aggregate (% of retained aggregate No.4 sieve)

FA = Fine aggregate (% of the aggregate passing the No.4 sieve retained on the No.8 sieve)

FF = Filler

K = Constant range of 0,5 – 1,0

ANALYSIS OF TEST RESULTS

Asphalt Material Test

The asphalt used in this research is BNA blend asphalt. The test was carried out in the laboratory of PT. Trijaya Cipta Makmur which includes penetration test, softening point, specific gravity, flash point and burn point. Table 1 shows the feasibility of modified asphalt for use in research. This can be seen from the results of the inspections that meet the requirements listed in the 2010 General Specification of Public Works of Highways Revision III.

Table 1. Test Results of BNA Blend Asphalt

No.	Type of Test	Unit	Specification		Test Results	Description
			Min	Max		
1	Asphalt penetration 25°C, 5 seconds	0,1 mm	50	75	54.5	OK
2	Softening point	°C	51	63	57	OK
3	Flash point	°C	232	-	335	OK
4	Weight loss	%weight	-	0,4	0,3	OK
5	Solubility in CCl4	%weight	99	-	105	OK
6	Ductility	Weight	100	-	110	OK
7	Penetration after weight loss	%	75	-	91,22	OK
8	Density	Gr/Cc	1	-	1,032	OK

Source: Trijaya Cipta Makmur Research Laboratory.

In identifying the optimum asphalt content (OAC), this study carried out several types of tests such as: VIM, VMA, VFB, stability, flow, and Marshal Quotient.

Table 2. Test Results of OAC determintation

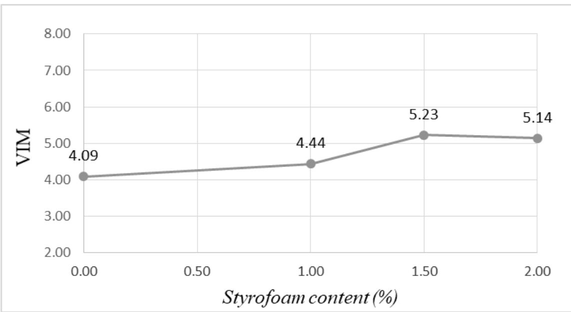
No.	Type of Test	Spec	Asphalt content to Marshall			
			4,5%	5%	5,5%	6%
1	VIM	3 – 5	6,52	5,53	5,01	**4,09**
2	VMA	Min. 15	**17,54**	**17,71**	**18,30**	**18,54**
3	VFB	Min. 65	62,82	**68,80**	**72,61**	**77,96**
4	Stability	Min 1000	**1222,76**	**1274,37**	**1282,31**	**1329,95**
5	Flow	Min. 3,0	**3,17**	**3,33**	**3,50**	**3,60**
6	Marshall Quotient	Min. 300	**386,13**	**382,31**	**366,37**	**369,43**

The number in bold indicates that the value meets the requirements by Bina Marga in 2010.

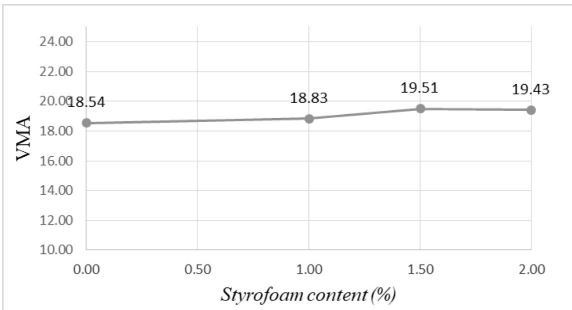
In the Marshall test as shown in Table 2, the optimum asphalt content was obtained at 6%. The Pb (initial design asphalt content) calculation obtained 5.6% and the closest asphalt content was 5.5 indicating the Marshall test results did not meet the specifications. Therefore, in this study, the asphalt content used for the comparison test with the addition of styrofoam was 6.0%.

Test Results with Styrofoam mixture

The greater the addition of Styrofoam into the asphalt, the higher VIM value which also occurred in some studies [4], [5]. If the VIM value is too high, it will result in reduced durability of the hard layer because the cavity is too large, it will facilitate the entry of water and air into the pavement layer. From Figure 4a) the VIM value that meets the 2010 Bina Marga specification is only 0% styrofoam content, which is 4.09 and 1% styrofoam content, which is 4.4% with the specification value of 3.0 -5.0



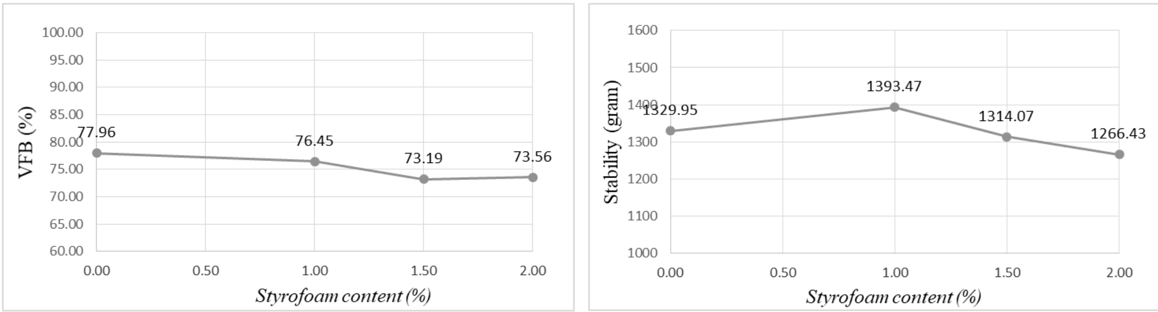
(a)



(b)

Figure 4 a) Relationship between Styrofoam Content and VIM, b) Relationship of Styrofoam Content with VMA

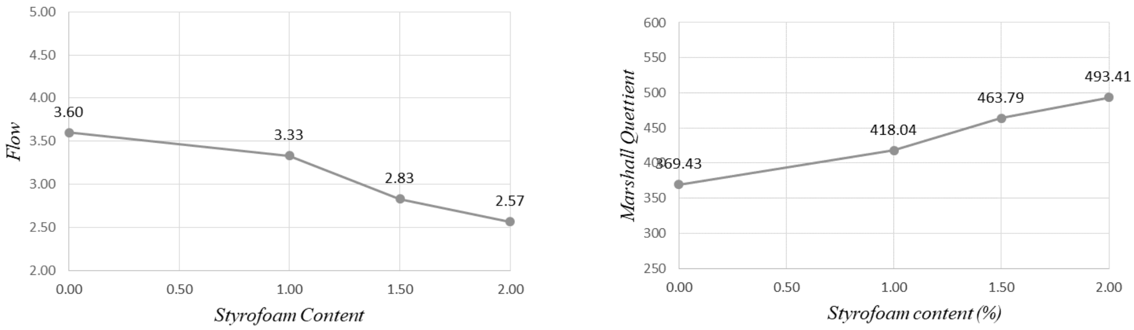
In this experiment, the greater the Styrofoam content, the higher the VMA value, indicating that the space to accommodate the asphalt and the volume of air voids required in the hot asphalt mixture is getting bigger. VMA specifications on the 2010 Bina Marga spec, which is a minimum of 15%. In this experiment the entire experiment met the specifications.



(a) (b)

Figure 5. a) Relationship between Styrofoam Content and VFB, b) Relationship of Styrofoam Content with Stability

In this experiment, the higher the Styrofoam content, the lower the VFB value, indicating that the water-tightness of the mixture was reduced due to a few voids filled with asphalt. The decrease in the value of VFA was caused by the increase in the value of the VMA. With the same amount of asphalt, if the value of voids between VMA aggregates is greater, the percentage of voids filled with asphalt (asphalt covering the aggregate) will be smaller [5], [18]. However, all levels are included in the 2010 Bina Marga specification, which is a minimum of 65%. In this experiment, the higher the styrofoam content, the lower the stability value, indicating that the higher the styrofoam content the asphalt cannot withstand deformation. However, in this experiment the results obtained still meet the 2010 Bina Marga specifications with a specification value > 1000 grams



(a) (b)

Figure 6.a) Relationship between Styrofoam Content and Flow, b) Relationship of Styrofoam Content with Marshall Quotient

The higher the styrofoam content, the lower the flow value until it does not meet the 2010 Bina Marga specification. It shows form the Fig. 6a that the increase in styrofoam content will cause the asphalt to not be able to wthstand the load so that it will cause deformation. The decrease in flow value when the addition of styrofoam also occurred in some studies [4] and some did not meet the standard values [19], [5]. In this experiment the values that meet the 2010 Bina Marga specifications are only 0% and 1% styrofoam contents with values of 3.60 and 3.33. As shown in Fig.6b in this experiment, the higher the styrofoam content, the higher the Marshall Quotien, indicating the stiffer the mixture and has a high stability value as shown in some results [5], [20]. In this study, the entire experiment met the 2010 Bina Marga specifications with a min value > 300.

CONCLUSIONS

The following conclusions can be drawn based on the analysis of the results in this study:

1. The use of styrofoam as an additive to the laston – WC pavement mixture can improve the quality of the road pavement. The results show that the more variations of styrofoam the more

filling the voids to envelop the aggregate, the remaining cavities in the mixture are getting smaller and the VIM value is decreasing.

2. From Marshall Test data, it was found that mixture with 1% styrofoam content meets all the requirements according to the specifications of the Ministry of Public Works in 2010. It obtained VIM of 4.44%, VMA of 19.14%, VFB of 76.82%, the stability value of 1393.47 kg, flow value of 3.33 mm, Marshall Quotient of 418.04 kg/mm.

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