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The Use Of Plastic Bag Waste As A Mixture Of Asphalt Concrete-Wearing Course (AC-WC) Using Scoria Basalt Aggregate

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Abstract

Every year, A huge of plastic waste is produced, however it needs a long time to decompose. By the use of plastic, it hopes the increase of asphalt mixture resistance against the temperature and elasticity while adding the scoria basalt rock as the aggregate. This study was conducted to determine the effect of using plastic bags as a mixture on the asphalt concrete-wearing course (AC-WC) using scoria basalt aggregate. The purpose of this study was to determine the characteristics of Marshall parameters after adding the plastic and scoria basalt aggregate in the asphalt concrete-wearing course (AC-WC) mixture. As the result, the value of Optimum Asphalt Content (KAO) obtained is 6.6%. Marshall parameters such as VIM, VFA, VMA, MQ and Flow have also met the requirements of the 2010 Highways Specification.

Keyword: plastic, Asphalt Concrete-Wearing Course (AC-WC), scoria basalt

Introduction

Nowadays, the existence of a highway for daily life is very needed. Apart from being a means of land transportation, a road also functions to facilitate the mobility and accessibility of road users. The essential thing in supporting the usability of the road is the quality and efficiency of the road pavement work. Pavement usually uses asphalt. Asphalt is a binder for road pavement mixtures which becomes the most important factor and affects the performance of asphalt mixtures, especially on flexible pavements. Beside it is easy to obtain, asphalt is more efficient and cheaper. Asphalt is the main ingredient of road pavement. The properties and production of asphalt materials do not change totally, especially in tropical climates such as Indonesia, indicating that asphalt has the potential to be an important material for road pavements.

The surface layer on asphalt concrete tends to be damaged quickly because the surface layer directly withstands the load of vehicles passing through the road. To prevent the road pavement surface damage which is caused by an overload and water, it could increase the binder, namely, a mixture of aggregates and other additives to improve the asphalt quality.

According to Mujiarto (2005), plastic is a polymer that has unique and remarkable properties. The use of plastic waste as a substitute and additive of asphalt mixtures is a positive idea to be developed and used as an additional material of infrastructure. Plastic also has some surpluses such as light, strong, and resistant to corrosion. Plastic waste can be used for road construction. One of the additives commonly used in this process is polymer. The plastics that often use in daily life contain polymers that are plastomer and have the potential to be used as road pavement additives.

Rajasekaran et al (2013) conducted a study using plastic in hot asphalt mixtures. The method used was the dry process, namely, the process of coating hot aggregate by melted plastic. The results showed that the aggregate coated with plastic did not only improve the mixture quality, but also improving the aggregate quality.

Tajudin and Suparma (2017) mention that the use of plastic in asphalt-concrete mixtures can increase the value of immersion stability even when the immersion is carried out for 7 days, so that the durability of the mixture with the use of plastic is better than without the plastic. According to Xiao et al., (2007), rutting damage in hot asphalt mixtures can be caused by two mechanical responses, namely melting or flow and plastic deformation. Plastic deformation emerges because the aggregate movement with each other is followed by the melting of the asphalt.

On the other hand, there are some materials found in nature that can be used as coarse aggregate in asphalt mixtures so that possible to improve performance such as durability and stability. The material is basalt rock. Therefore, this study discusses the performance of a mixture of plastic waste and scoria basalt aggregate as an asphalt mixture that has additional value.

Research Method

The materials used were white plastic bags, scoria rock from East Lampung as aggregate. The plastic used was a white plastic bag. The plastic, then, was sorted, cleaned and chopped into smaller pieces. Furthermore, it is burned/melted firstly before being mixed with liquid asphalt and aggregate. The asphalt sample was then carried out by the Marshall test. This test was firstly developed by Bruce Marshall (1939) and then completed by Engineers from the Watering Experiment Station (WES) in 1943.

This test was carried out by measuring the resistance to load application on a cylindrical specimen with a diameter of 4 inches and a height of 2.5 inches. Two values were measured from the Marshall test: the stability value obtained from the load required to fail the sample, and the flow value obtained by measuring the vertical distortion required to fail the sample.

Discussion

Marshall test results on each variation of plastic and basalt rock and their relationship with asphalt content are presented in Table 1. Marshall test is used to determine the value of stability, flow, and marshall quotient (MQ) of the mixture. In this test, the duration of immersion of the test object in a water bath with a constant temperature of 60°C is 30 minutes and 24 hours.

Relationship between stability and asphalt content

The relationship between stability and asphalt content is shown in Figure 1. In the stability parameter, it can be seen that the highest average stability value was obtained, namely, 950 kg. Stability testing is to measure the resistance of the mixture toward the load, the greater the stability value, the higher the resistance of the mixture toward the load. The measurement was made by placing the test object on the Marshall tool.

The stability value requirement is more than 800 kg. Pavement layers with a stability value of less than 800 kg will easily experience rutting, because the pavement is soft so it could not possible to support the load. On the contrary, if the pavement stability is too high, the pavement will crack easily because the pavement is stiff.

Relationship between melting and asphalt content

The asphalt melting parameter shows a decrease in the asphalt melting value while increasing the asphalt content used. In this parameter, the meltinh value that meets the specifications is only at a level of 2.4% as shown in Figure 2. A low flow value will cause a stiff so that the pavement layer becomes easy to crack, while a mixture with a high flow value will produce a plastic pavement layer so that the pavement will easy to change shape such as washboarding and rutting.

Relationship between VIM and asphalt content

The relationship between VIM and asphalt content is presented in Figure 3. Voids in Mix (VIM) is a parameter of voids in the mixture. VIM is the percentage of voids exist in the mixture. Air voids are needed to provide space for the elements in the mixture when the pavement temperature is high. In this parameter, the linear graph is inversely proportional. In this parameter, the value of voids in the mixture that meets the specifications is only in the range of asphalt content of 6.4-6.9%. The requirement of the VIM value is 3.5-5%. A VIM value that is too low will cause bleeding because at high temperatures the asphalt viscosity decreases based on the thermoplastic properties. The VIM value affects the durability of the pavement layer, the higher the VIM value indicates the larger the cavity in the mixture so that the mixture is pourous.

Relationship between VMA and asphalt content

The relationship of asphalt content in the test to the VMA value can be seen in Figure 4. The presence of plastic waste and scoria basalt causes the increase of mixed cavity and enlarges the VMA value. The form of the graph obtained is a semi-linear graph that is directly proportional. In this parameter, the value of voids between aggregates that meet specifications is in the range of 6-8%. VMA (Void in Mineral Aggregate) is the cavity between the aggregate grains on a pavement, including air voids and the effective asphalt volume (excluding the asphalt volume absorbed by the aggregate). The VMA value is influenced by compaction factors, namely the amount and temperature of compaction, aggregate gradation, and asphalt content. This VMA value affects the impermeability of the mixture toward the water and air as well as the elastic properties of the mixture. Besides, it can also be stated that the VMA value determines the value of stability, flexibility and durability.

Relationship between VFB/VFA and asphalt content

Voids filled asphalt is a parameter of voids filled asphalt. The relationship between VPB/VPA and asphalt content is shown in Figure 5. The obtained semi-linear graph is directly proportional and the graph corresponds to a typical graph which is also proportional. This parameter corresponds to the minimum value of 65%, where all cavity values meet the specifications. The required VFA value is a minimum of 63%. This value reveals the percentage of mixed voids containing asphalt, the value will increase based on the increase of asphalt content to a certain extent, where the voids are full. This means that the voids in the mixture have been completely filled with asphalt, then the asphalt content percentage that fills the voids is the percentage of maximum asphalt content.

A VFA value that is too small will cause the less impervious mixture toward the water and air because the asphalt film layer will become thin and will crack easily when receiving additional loads so that the asphalt mixture is easily oxidized which ultimately causes the pavement layer does not last long.

Relationship between MQ and asphalt content

After analyzing the Marshall test, and obtaining Marshall characteristic values, a graph of the relationship between asphalt content and characteristic values was made. Based on the graph and comparison to the specifications required by Highways, the optimum mix asphalt content was determined.

Figure 6 shows the relationship between MQ and asphalt content. MQ (Marshall Quotient) is the quotient between stability and flow value. MQ can indicate an approach to the strength and flexibility of an asphalt mixture. The addition of plastic and basalt scoria causes the increase of MQ value. This shows that the use of plastic in asphalt mixtures can increase the MQ value, which means the mixture is stiff and has low flexibility so that the mixture will crack easier. Figure 7 shows the area of asphalt content in which the value of each characteristic of the mixture meets the specifications of Highways so that KAO can be determined. Optimum asphalt content (KAO) is taken at the median value of asphalt content that meets the requirements. Based on the figure, the optimum asphalt content is 6.6% asphalt content.

Conclusion

From the results of data analysis in this study, it can be concluded that the Optimum Asphalt Content Value (KAO) obtained is 6.6%. This value was obtained from the average asphalt content of the test object group I (middle gradation) and test object group II (upper limit gradation) which met all Marshall parameter requirements.

REFERENCES

Anonim, 2010.Spesifikasi umum 2010 Devisi 6 Perkerasan Beraspal. Direktorat Jendral Bina Marga Kementerian Pekerjaan Umum. Jakarta

Mujiarto, Iman. 2005. Sifat dan Karakteristik Material Plastik dan Bahan Aditif. Semarang :AMNI.

Sukirman, Silvia. 1999. Perkerasan Lentur Jalan Raya. Bandung. Nova.

Rajasekaran, S., Vasudevan, R., & Paulraj, S. (2013). Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite for Road Application—Green Method. American Journal of Engineering and Research, 2, 1-13.

Tajudin, AN. (2013). Pemanfaatan Limbah Plastik HDPE Sebagai Agregat Kasar Pengganti Pada Campuran Asphalt Concrete Binder Course (ACBC), Skripsi, Universitas Gadjah Mada.

Xiao, F., Amirkhanian, S., & Juang, C. H. (2007). Rutting resistance of rubberized asphalt concrete pavements containing reclaimed asphalt pavement mixtures. Journal of Materials in Civil Engineering, 19(6), 475-483.

Table 1. Characteristics of Marshall Test Results

Criteria	Specification	Test Result
Standard mixed solid density (Bulk Density)	-	2.345
Mixed maximum density (GMM)	-	2.439
Optimum asphalt content	-	6.60
Cavities in the mixture 75 x 2 impact (VTM)	3-5	3.85
Cavity in aggregate (VMA)	Min. 14	16.54
Asphalt filled cavity (VFA/VFB)	Min. 65	76.72
Cavity baling density 400 x 2 collision(PRD)	Min. 2	3.80
Marshall Stability (Stability)	Min. 1000	953.3
Marshall Melt (Flow)	2.0-4.0	2.43
Results for Marshall (MQ)	Min. 250	394
The stability of the remaining 24 hours of immersion at a temperature of 60 oC (IKS)	Min. 90%	93.71

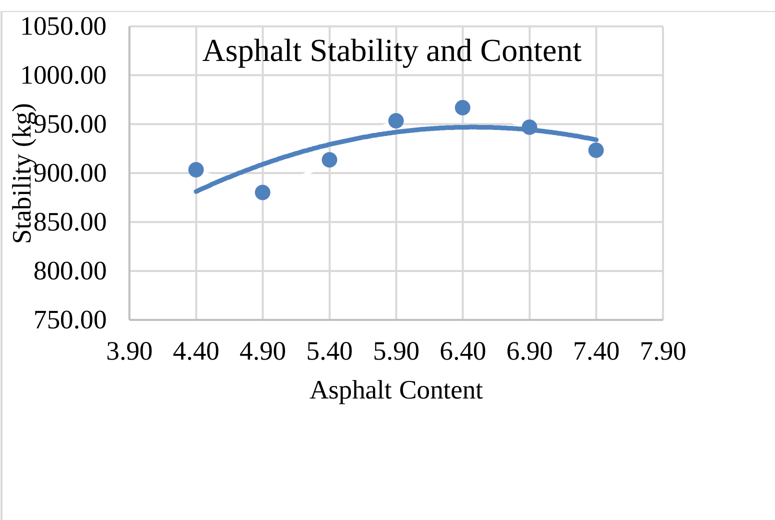

Figure 1.Relationship between stability and asphalt content

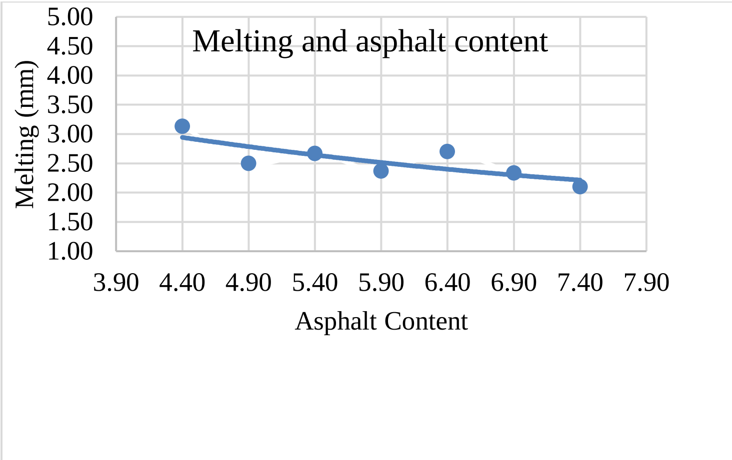

Figure 2.Relationship between melting and asphalt content

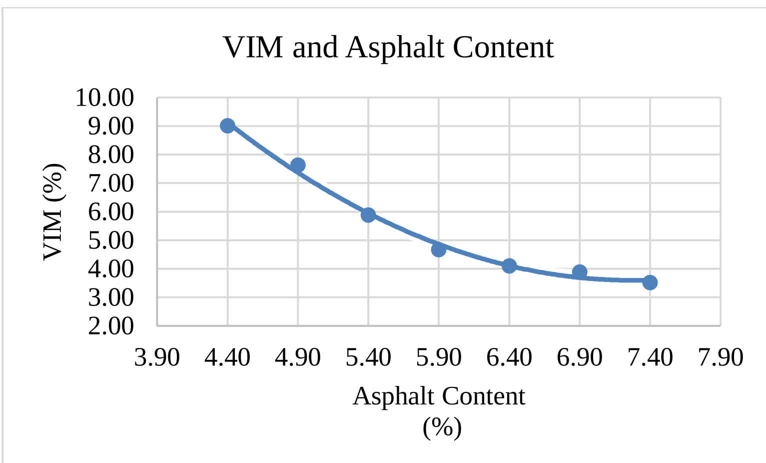

Figure 3.Relationship between VIM and asphalt content

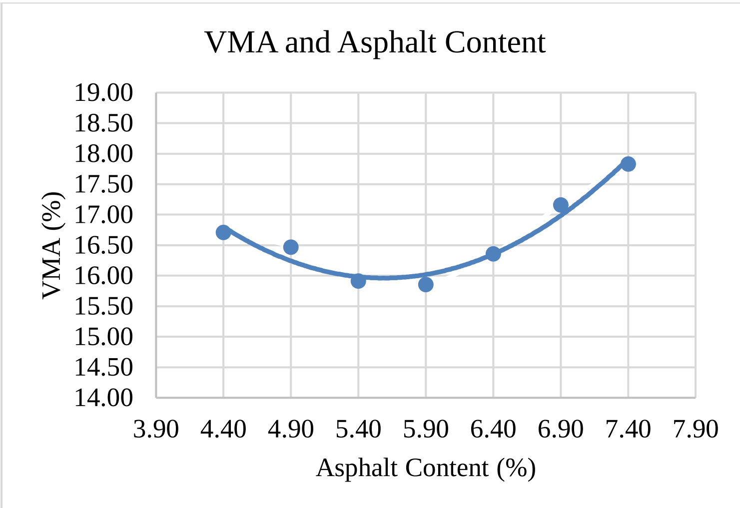

Figure 3.Relationship between VMA and asphalt content

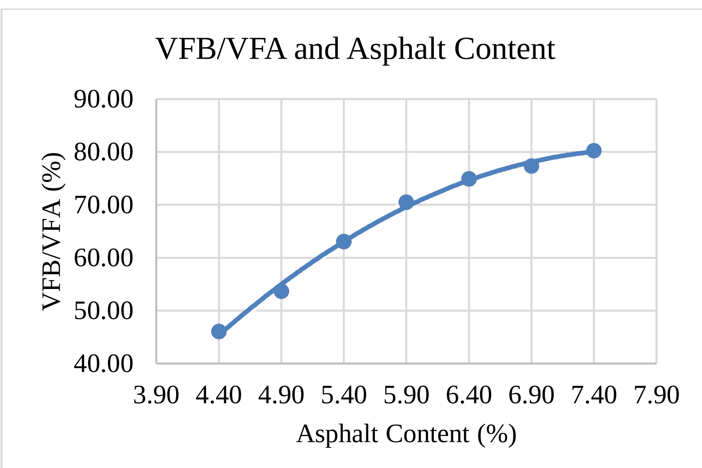

Figure 5. Relationship between VFB/VFA and asphalt content

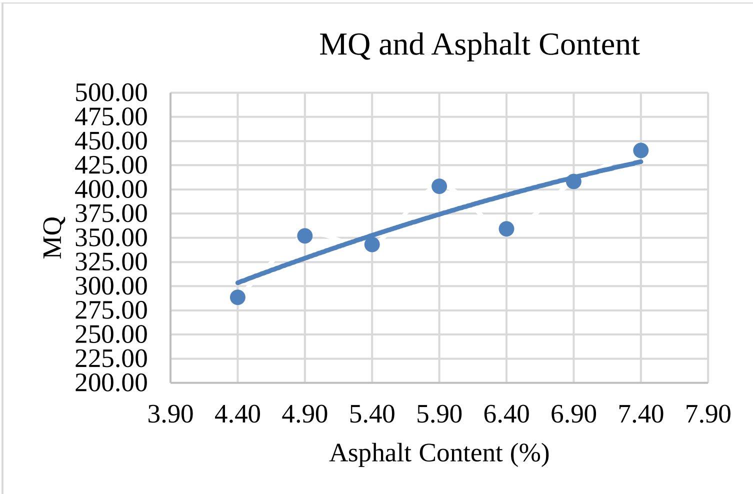

Figure6. Relationship between MQ and asphalt contentFigure

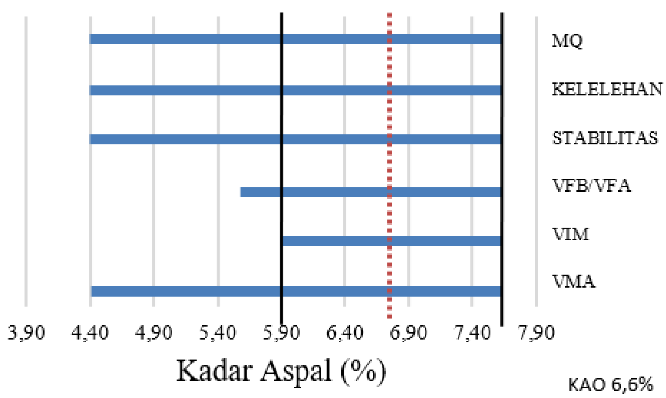

Figure 7. Optimum asphalt content