3_RECLAIMED ASPALT

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Experimental Study on the Effects of Reclaimed Asphalt Pavement towards Marshall Parameters on Asphalt Course-Wearing Course

Experimental Study on the Effects of Reclaimed Asphalt Pavement towards Marshall Parameters on Asphalt Course-Wearing Course

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Abstract. Road pavement is one of the most important parts to provide better transportation services, for humans and or goods. To get a good road pavement, proper asphalt mixture design is needed under the required standards. In designing asphalt mixture, a large amount of materials is needed but, those materials will not be available forever. With those material limitations, alternative material is needed as a substitute, especially waste materials. One of the alternative material that could be useful is Reclaimed Asphalt Pavement (RAP). This study aims to determine the effect of RAP towards asphalt concrete mixture, based on its Marshall parameters. The method that was used in this study is a stability test, using Marshall Method. The test was carried out on asphalt concrete mixtures with four different types of RAP content, which were 25%, 50%, 75%, and 100% and with an optimum asphalt content of 5,5%. Based on these results, it was found that with the addition of RAP, it could increase the stability value of asphalt concrete, with an optimum content of RAP that can be used is 52,08%. The result shows that not only RAP could be used as an alternative, but also gives good results towards the stability value of asphalt concrete.

1. Introduction

Road pavement is one of the supporting infrastructures to provide good transportation services for humans and or goods. To get a good road pavement, proper asphalt mixture design is needed under the required standards. In designing the right asphalt concrete mixture, a large amount of materials is needed but in reality, these materials have limitations in terms of availability [1]. Based on this problem, an alternative material is needed. One of the alternative material that can be utilized is a construction waste material, namely Reclaimed Asphalt Pavement or RAP. RAP itself is the result of construction waste that used or discarded. The existence of RAP itself as a construction waste will cause environmental problems, so there needs to be an effort to reduce the presence of RAP waste.

This study aims to determine the effect of RAP as a substitute for natural aggregate in asphalt concrete, based on its Marshall parameters. The results of this study hopefully can provide consideration for RAP to be used as a substitute for natural aggregates.

2. Literature Study

2.1. Road Pavements

Road pavement is a layer of pavement that is located in between the soil layer and vehicle wheels. Road pavement acts as a load carrier. Road pavements also have their own planned duration service so that if

there is damage before the planned duration service ends, reparation must be conducted to maintain the quality of it. Based on its binding material, road pavements are divided into 3 types. Those types are flexible pavement, rigid pavement, and composite pavement [2].

2.2. Concrete Asphalt

Concrete asphalt is a road construction layer that is formed from a mixture of asphalt along with natural aggregates. Concrete asphalt has a little void and the materials that form it have strong bonding properties, which make the concrete asphalt not only be relatively rigid but also have a high stability value. Based on its function, concrete asphalt is divided into 3 types. Those types are asphalt concrete-wearing course (AC-WC), asphalt concrete-bearing course (AC-BC) and asphalt concrete-base . Asphalt concrete-wearing course is a layer of concrete asphalt, which acts as a layer of wear. This layer is connected directly to the wheels of the vehicle that is located above.

2.3. Reclaimed Asphalt Pavement (RAP)

RAP or Reclaimed Asphalt Pavement is material that is obtained through an old road pavement layer, by way of dredging. RAP can be reused partly or fully as a substitute material to create new road pavement layers. RAP can be used as a replacement because the aggregates that were contained in the RAP can still function as aggregates in the newer mixture [3]. There are several benefits in using RAP as an alternative, such as cost savings and also it could help in energy conservation. Based on its process, the recycling method for RAP can be divided into two, namely cold mix recycling and hot mix recycling. Meanwhile, based on its location, the recycling method for RAP can be divided into in-site recycling and in-plant recycling [4].

2.4. Marshall Test and Parameters

To find out about the characteristics of an asphalt mixture, a test is conducted with the help of Marshall tool [5]. Characteristics of an asphalt mixture can be divided into several parameters. These parameters are stability, flow, void in mixture, void in mineral aggregates, void filled with asphalt and Marshall Quotient [4-6]. Stability can be defined as an ability measurement of a concrete asphalt to withstand deformation due to workloads. Stability is an ability measurement for concrete asphalt to withstand deformation due to workload. Void filled with asphalt or VFA is a percentage value of air voids that exist in between aggregates that are filled with asphalt but it does not include the asphalt that is absorbed by aggregates [7-8]. Void in mineral aggregates or VMA is a percentage value of air voids that exist in between aggregates. Void in mix or VIM is a percentage value of air voids that exist as a whole in a concrete asphalt. Marshall Quotient is the ratio between stability value and flow. The higher the value of MQ, the more rigid concrete asphalt could be and it will become more susceptible to damage [9-10].

3. Research Method

The research method that was used in this study is in Figure 1.

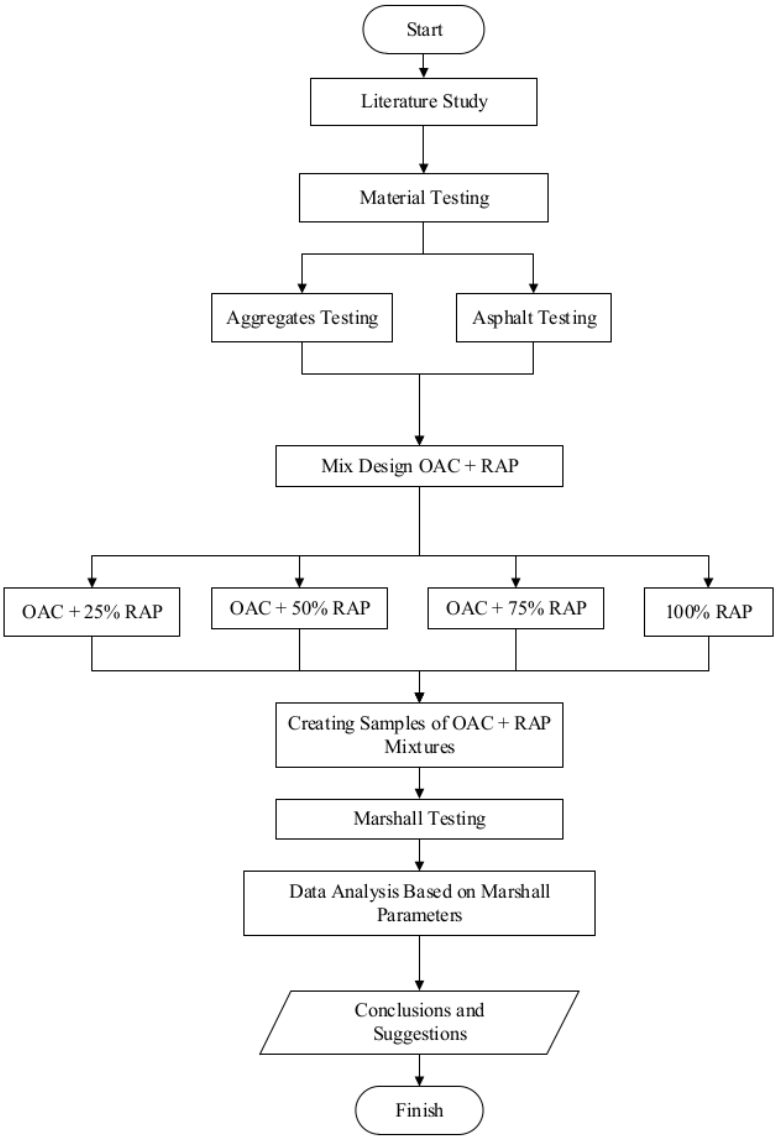

Figure 1. Research Method Diagram

4. Results and Analysis

Before the design of concrete asphalt mixture, several tests were carried out towards the materials that are going to be used in this study. These tests aim to determine the quality of the materials that are going to be used. The tests were carried out on natural aggregates and also asphalt. Based on the results, it can be concluded that the materials have met the required standards.

4.1 Marshall Test Results

In Table 1, it shows the results from the Marshall test on concrete asphalt mixture with each RAP content. The results are then going to be compared with the results from the Marshall test on optimum asphalt content. The effects of adding RAP on concrete asphalt mixture, along with the difference

between it and the results from normal concrete asphalt mixture is presented in the diagram in Figure 2-7.

Table 1. Marshall Test Results for Concrete Asphalt Mixture with RAP Addition

RAP Content	VIM (%)	VMA (%)	VFA (%)	Stability (kg)	*Flow* (mm)	MQ (kg/mm)
RAP 25%	3.74	13.03	71.42	2578.80	4.37	590.57
RAP 50%	3.81	13.32	71.82	2422.56	4.30	563.39
RAP 75%	2.80	13.03	80.03	2402.68	8.87	270.98
RAP 100%	2.04	14.20	85.71	1710.91	8.30	206.13

4.2. Comparison Analysis Results

Figure 2 is a comparison diagram of concrete asphalt mixtures before and after the addition of RAP, based on its stability value. Based on the Figure 2, it is found that with the addition of RAP, it increases the stability value up to a certain point, which in this case it increases up to the 75% addition of RAP before it drops down when it hits the 100% use of RAP. The biggest increase in stability value comes from the mixtures with a 25% addition of RAP, which is 12.28%. The result in the Figure 2 shows that if the stability value in concrete asphalt mixture rises, the concrete asphalt will have a good performance.

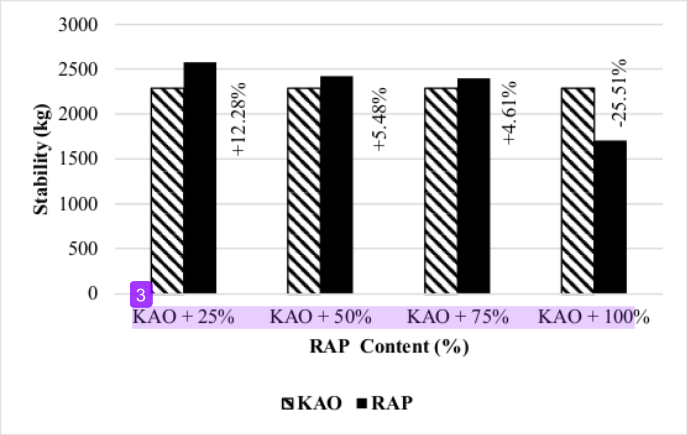

Figure 2. Stability Value Comparison

Figure 3 is a comparison diagram of concrete asphalt mixtures before and after the addition of RAP, based on its flow. Based on the Figure 3, it is found that with the addition of RAP, it increases the flow up until 100% addition of RAP. The biggest increase in flow value comes from the mixtures with 75% addition of RAP, which is 155.62%. The result in the Figure 3 shows that with more RAP being added to the mixture, the flow value of concrete asphalt will go up and it will make it become more plastic and will be easier to deform [11].

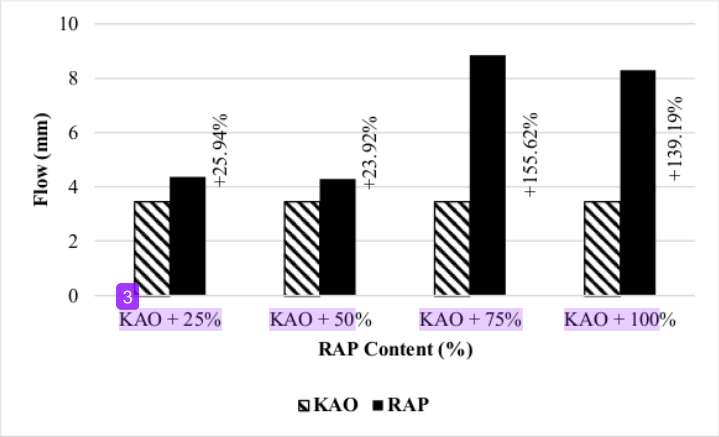

Figure 3. Flow Value Comparison

Figure 4 is a comparison diagram of concrete asphalt mixtures before and after the addition of RAP, based on its VIM value. Based on the Figure 4, it is found that with the addition of RAP, it lowers the VIM value up until 100% addition of RAP. The biggest decrease in VIM value comes from the mixtures with 100% addition of RAP, which is 48.47%. The result in the Figure 4 shows that with more RAP being added to the mixture, the VIM value will be less and based on that, the voids in concrete asphalt mixture will also become less [12].

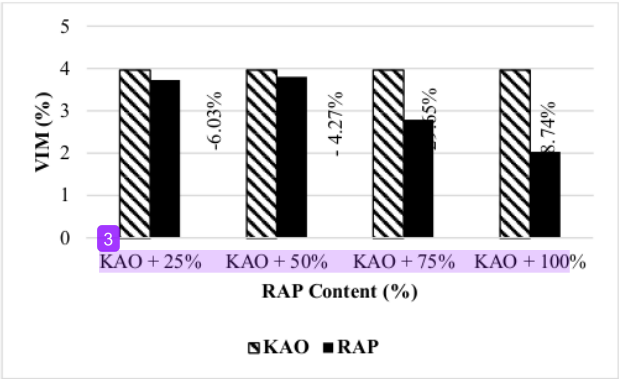

Figure 4. VIM Value Comparison

Figure 5 is a comparison diagram of concrete asphalt mixtures before and after the addition of RAP, based on its VMA value. Based on the Figure 5, it is found that with the addition of RAP, it lowers the VIM value up until 100% addition of RAP. The biggest increase in VMA value comes from the mixtures with 25% and 75% addition of RAP, which is 15.17%. The result in the Figure 5 shows that with more RAP being added to the mixture, the VMA value will be less and based on that, the voids in between mineral aggregates on concrete asphalt mixture will also become less [13].

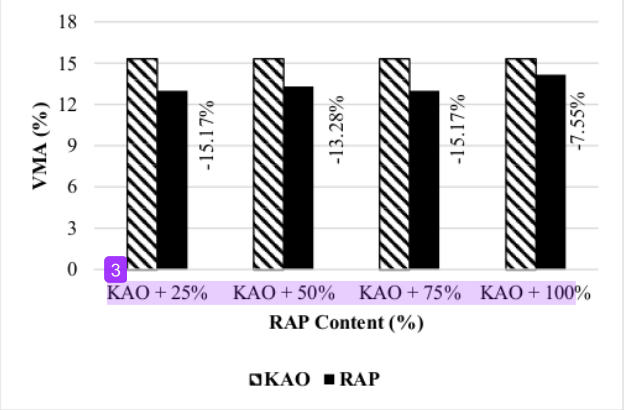

Figure 5. VMA Value Comparison

Figure 6 is a comparison diagram of concrete asphalt mixtures before and after the addition of RAP, based on its VFA value. Based on the Figure 6, it is found that with the addition of RAP, it had various results in which with 25% and 50% addition of RAP, the VFA value decreases up to 3.59% while with 75% and 100% addition of RAP, the VFA value increases up to 15.70%. These varied results can be caused by several factors such as compacting process, the content of asphalt that was used and room temperature when samples were being cooled off [14-15].

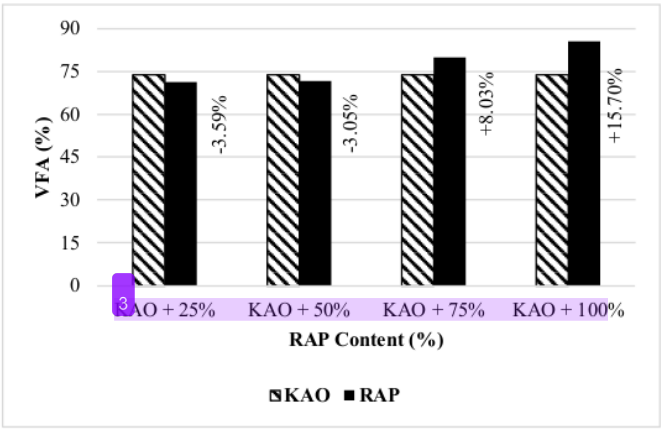

Figure 6. VFA Value Comparison

Figure 7 is a comparison diagram of concrete asphalt mixtures before and after the addition of RAP, based on its Marshall Quotient value. Based on the Figure 7 it is found that with the addition of RAP, it lowers the VIM value up until 100% addition of RAP. The biggest decrease in VIM value comes from the mixtures with 100% addition of RAP, which is 68.89%. The result in the Figure 7 shows that with more RAP being added to the mixture, the Marshall Quotient value will be less and based on that, the concrete asphalt mixture will become more plastic [16-17].

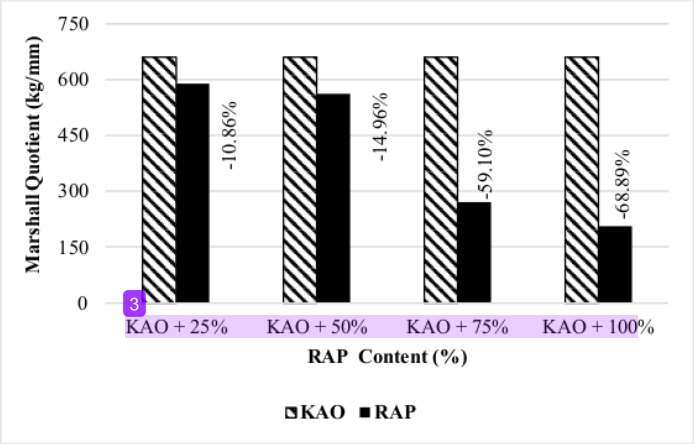

Figure 7. Marshall Quotient Value Comparison

5. Conclusions and Recommendations

5.1. Conclusions

Based on the study that has been conducted, the following conclusions are obtained:

a.) The use of RAP on concrete asphalt mixture increases the stability value, with the biggest rise comes from 25% addition of RAP, in which the stability value increases by 12.28%. This result makes the concrete asphalt to become stronger and more susceptible to a bigger workload.

b.) The use of RAP on concrete asphalt mixture increases the flow value up until 100% addition of RAP, with the increase can go up to 155.62%. This result makes the concrete asphalt to become more plastic and easier to deform.

c.) The use of RAP on concrete asphalt mixture lowers the VIM value up until 100% addition of RAP, with the decrease can go up to 48.47%. This result makes voids in concrete asphalt mixtures to become less.

d.) The use of RAP on concrete asphalt mixture lowers the VMA value up until 100% addition of RAP, with the decrease can go up to 15.71%. This result makes voids in mineral aggregates on concrete asphalt mixtures to become less.

e.) The use of RAP on concrete asphalt mixture gives of various results, in which with the 25% and 50% addition of RAP, it lowers the VFA value while with the addition of 75% and 100% RAP, it increases the VFA value. This result can be caused by several factors such as compacting process, asphalt content and room temperature.

f.) The use of RAP on concrete asphalt mixture lowers the Marshall Quotient value up until 100% addition of RAP, with the decrease can go up to 68.89%. This result makes the concrete asphalt mixtures to become more plastic.

5.2. Recomendations

Based on the study that has been conducted, the following suggestions are obtained**:**

a.) Based on high stability numbers that are obtained, it can be suggested that research can be conducted on the effects of RAP towards asphalt concrete-base mixtures.

b.) There needs to be further research in regards to the durability and life service on the concrete asphalt mixtures, because of the low VIM, VMA, flow and Marshall Quotient numbers.

c.) A further research needs to be conducted in regards to the RAP material to provide more details towards the material.

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