Asphalt Concrete Mix Performance-Wearing Course (AC-WC) using Concrete Waste as Course Aggregate with the Addition of Wetfix-Be

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ABSTRACT
The impact of high rainfall and uncontrolled traffic loads, it is necessary to conduct research on the use of concrete waste materials as a substitute for coarse aggregates in order to reduce the limitations of natural aggregates and wetfix-be additives with the aim of increasing performance, strength, durability, stability, and AC-WC mixed resistance. This research was conducted using variations of 0%, 40%, 80% and 100% concrete waste. Variations of additives are 0.15%, 0.25%, 0.35% and 0.45% by weight of asphalt. The value of normal asphalt content obtained was 5.35% and the optimum asphalt content of 100% concrete waste was 5.60%. Marshall characteristic values include stability, flow, density, VFA and VIM, namely the variation using 100% concrete waste and wetfix-be additives (1322,617 kg, 3,883 mm, 2,222 gr / ml, 49,731 %, 12,225 %). normal variation (998.23 kg, 3,311mm, 2.455 gr / mm, 77,519 %, 3,672 %). Based on the results of the analysis, the variation of the mixture of 100% concrete waste and the addition of 0.25% wetfix-be has good durability.

Keywords: *Concrete waste, wetfix-be, marshall characteristic, durability*

1. INTRODUCTION

Asphalt pavement currently used in Indonesia is made of Hot Mixed Asphalt. According to the General Specifications of the Ministry of Public Works in 2010 [1], the type of asphalt mixture was divided into three parts, namely: Thin Asphalt Sand (Sand Sheet), Thin Asphalt Concrete (Hot Rolled Sheet) and Asphalt Concrete (Asphalt Concrete).One type of flexible pavement construction layer is asphalt concrete layer (LASTON), this layer consists of aggregate and asphalt as a binder which will be mixed at a certain temperature and evenly. Laston is divided into three types, namely Laston as a wear layer known as AC-WC (Asphalt concrete - Wearing Course), Laston as a binder layer known as AC-BC (Asphalt Concter-Binder Course), and Laston which functions as a foundation layer called with AC-Base (Asphalt Concrete-Base).AC-WC is a type of surface layer that is directly related to vehicle tires so that this layer is designed to withstand weather changes, vehicle tire pressure, shear forces and can provide a waterproof layer for the layer underneath. The choice of material is very important because the performance of the AC-WC mixture is very dependent on the type and quality of the constituent material. However, because the amount of available aggregate material is increasingly limited, it is necessary to make new efforts to find alternative materials that can be used as a substitute for aggregates that are obtained easily and cheaply to overcome the depletion of natural aggregate availability in Indonesia. Therefore this study uses concrete waste as a substitute for coarse aggregate. Concrete waste that is used is the remains of building debris due to natural disasters, building demolition, failure in the manufacture of concrete in factories or from testing the compressive strength of concrete in laboratories, which are large in number and are not reused, so it is necessary to use them. Previous research has explained that concrete waste can be used as a substitute for aggregate in asphalt mixtures with a composition of 100% as a substitute for grade aggregate and has succeeded in increasing the stability of the mixture by 46.8% [2]. However, it has a high absorption value so that additional substances are needed which can reduce the absorption capacity of concrete waste [3]. Besides, the use of Wetfix-Be can increase the value of VMA, VIM, MQ and Marshall Stability [4]. Wetfix-Be serves to increase the adhesion of aggregates and bonds, as well as reduce the negative effects of water and moisture. This creates a high adhesion surface finish [5]. So that the additive used in this study is Wetfix-Be.

2. RESEARCH METHOD

The research method used in this study is an experimental method in the laboratory. The materials used are coarse aggregate, fine aggregate, rock ash, asphalt and Wetfix-be additives. The aggregate material is taken from AMP PT.TMPI Subang, with standard grain diameter for AC-WC type pavement layers. While the concrete waste comes from the rest of the concrete compressive strength test that is no longer used with a concrete quality of f'c 30 Mpa. Asphalt used hard asphalt type 60/70 penetration PT. TMPI Subang which is adapted to the natural conditions of Indonesia, which is based on the General Specifications of Highways in 2018 [6]. The wetfix-be additive comes from PT. Enceha Pasifik, Jakarta. The stages of the research carried out were the preparatory work consisting of a mixture of hot asphalt, namely aggregate and asphalt. All materials to be used must be available with the required amount of research. Besides that, it also prepares a test site, testing equipment and types of testing. Then conduct an inspection for each material aggregates, asphalt and additives. The aggregate inspection is carried out using the Indonesian National Standard while the asphalt uses the 2018 Bina Marga Specifications. If the requirements as a hot asphalt mixture are met according to the specifications, it is followed by an inspection of the material which is the design data for the composition of the hot asphalt mixture by planning an estimated optimum asphalt content plan (Pb). Then the analysis of the criteria for Marshall examination is by examining the gradation and specific gravity of the test object and continued with the design of the type of mixture to be used, conducting volumetric analysis, immersion at two different times, namely at a temperature of 30 minutes and 24 hours, 48 hours of drying and saturation. Then performed stability and flow testing from Marshall testing. Then, the determination of the best composition criteria for each mixture. Then the Marshall criteria and quantities are analyzed for differences. The variation of the concrete waste mixture used is 0%, 40%, 80% and 100%. While the Wetfix-Be mixture variation is 0.15%, 0.25%, 0.35%, and 0.45% by weight of asphalt. The entire material preparation activities up to AC-WC mixing can be seen in Table 1. As follows:

Table 1. Number of Research Objects

Bitumen content	**Normal AC-WC**	**AC –WC with a variety of concrete waste**		
		40%	**80%**	**100%**
A. Marshall Test				
4,5	3	3	3	3
5,0	3	3	3	3
5,5	3	3	3	3
6,0	3	3	3	3
6,5	3	3	3	3
B. Gravity Maximum of Mixed (GMM) Test				
4,5				
5,0	5	5	5	5
5,5				
6,0				
6,5				
C. Immersion Index Test (IP)				
30 minute	3	3	3	3
24 hour	3	3	3	3
D. Marshall Test with Optimum Concrete Waste Level				
Bitumen content	0,15 % Wetfix-be	0,25% Wetfix-be	0,35 % Wetfix-be	0,45% Wetfix -be
Optimum	3	3	3	3
GMM	1	1	1	1
IP	6	6	6	6

Figure 1 Concrete Waste Aggregate Weighing Process

Figure 2 Asphalt Weighing Process

Figure 3 Marshall Test Object and Marshall Test

3. ANALYSIS METHOD

3.1. Stability

Miller et al. [7] Stability is the ability of road pavements not to experience permanent deformation, grooves or bleeding while servicing passing vehicles. The stability of the mixture depends on the internal friction force. Furthermore, the friction force between the aggregate grains is closely related to the properties of the aggregate. Friction and binding forces can withstand the movement between aggregate grains due to traffic loads.

3.2. Durability

Asphalt Institute [8] Durability is the durability or ability of a pavement to several factors such as changes in bitumen caused by the removal of the bitumen layer from the aggregate due to wet conditions and traffic loads, aggregate oxidation and disintegration. This parameter is called the Durability Index. In this method, the immersion time is ½, 24 and 48 hours.

4. RESULT AND DISCUSSION

4.1. Test Result

The test results of the asphalt mixture using concrete waste as a substitute for coarse aggregate and the wetfix-be added material are presented in graphic form in the test results section.

4.2. Discussion of test result

Discussion of the test results was carried out on the stability and ductility mode of the asphalt mixture in this study.

4.2.1. Aggregate test results.

Aggregate testing carried out at the POLBAN Road Pavement Materials Laboratory is testing the density of coarse aggregates, fine aggregates, absorption and abrasion testing. The results of specific gravity testing and absorption of coarse and fine aggregates can be seen in Tables 2, 3 and 4.

Table 2. Coarse *aggregate* test results

No	Type of Testing	Specification	Result
1	Specific Gravity (gr/cc)	Min 2,5	2.68
2	Absorption (%)	Max 3	2.15
3	Abrasion with Los Angeles machines (%)	Max 30	14.17
4	Aggregate Adhesiveness to bitumen (%)	Min 95	100

Table 3. Fine aggregate test results

No	Type of Testing	Specification	Result
1	Sand Equivalent Value (%)	Min 50	92,6
2	Absorption (%)	Max 3	2.15
3	Specific Gravity (gr/cc)	Min 2,5	2,67
4	Sieve passes material No 200(%)	Max 1,0	0,63

Table 4. Concrete waste aggregate test results

No	Type of Testing	Specification	Result
1	Specific Gravity (gr/cc)	Min 2,5	2,61
2	Absorption (%)	Max 3	3,7
3	Abrasion with Los Angeles machines (%)	Max 30	32,7
4	Flat index (%)	Max 5,0	2,19

Table 5. Pen 60/70 asphalt test results

No	Type of Testing	Specification	Result	Info
1	Specific Gravity	≥1,0	1,03	Ok
2	Ductility on 25ºC, 5 cm/minute	≥100	100	Ok
3	Soft spot	≥48	48.8	Ok
4	Viscosity Kinematic 135°C		330	Ok
5	Penetration on 25º C, 100 gr, 5 sec	60-70	62.7	Ok
6	Flash point (COC	≥232	329	Ok
7	Residue Penetration on25o C, 100 gr, 5 sec (% pure)	≥54	78,9	Ok

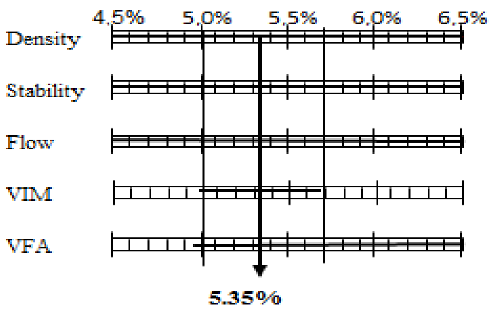

Figure 4 The optimum bitumen content (KAO) in narrow range method

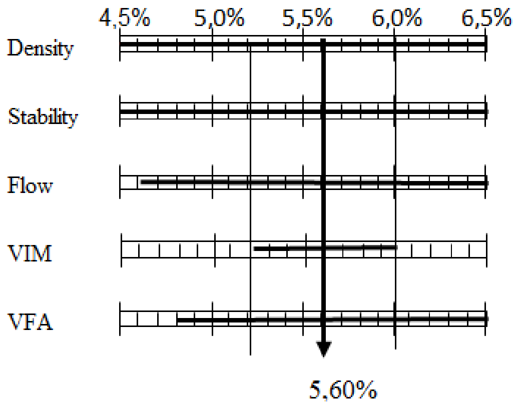

Figure 5. Asphalt content of concrete waste in narrow range method

4.2.2. The effect of adding concrete waste to marshall parameters

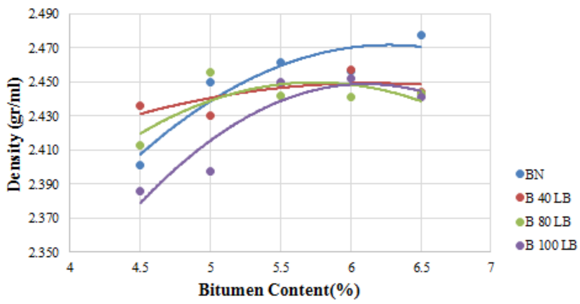

Figure 6 The density value of the asphalt mixture

Figure 6 shows that the density increases with increasing asphalt content, reaches a maximum value and then decreases again. From the density test results, it can be seen that the density of the normal asphalt mixture is higher than the density value of the modified asphalt mixture using concrete waste. The higher density value, the denser asphalt mixture.

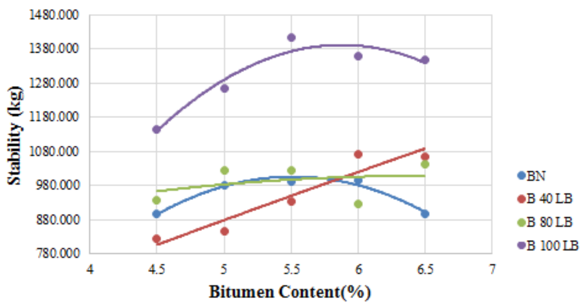

Figure 7 The stability value of the asphalt mixture

Figure 7 shows that the relationship between the variation of asphalt content and the stability value for the variation of concrete waste shows that the increase in the level of concrete waste will increase the stability value of the asphalt mixture, but at a greater level of 6%, it can be seen that the stability has decreased. The decrease in mixture stability above the maximum is related to the decrease in adhesion between the aggregate and the asphalt [9].

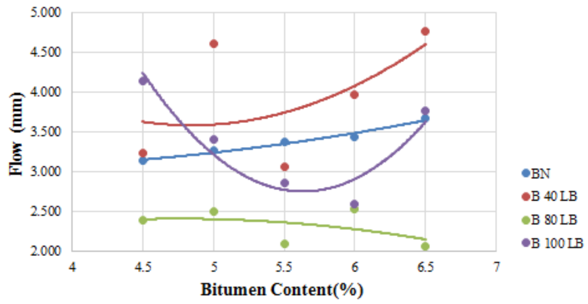

Figure 8 The flow value of the asphalt mixture

In Figure 8, it can be seen that the normal asphalt mixture and the use of concrete waste mixture 40% increases with the increase in asphalt content, but the 80% and 100% variation of asphalt mixture of concrete waste decreases with increasing asphalt content. This shows that 80% and 100% modified asphalt mixtures tend to be stiff and brittle.

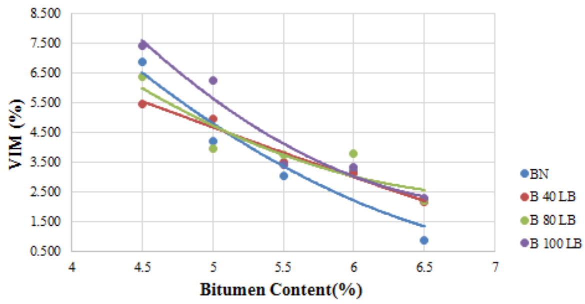

Figure 9 The VIM value of the asphalt mixture

The graph in Figure 9 shows that the VIM value has decreased with increasing levels of asphalt used. A small VIM value will result in an impermeable mixture thus increasing the mixture's ability to peel. However, this research is in accordance with the specifications used.

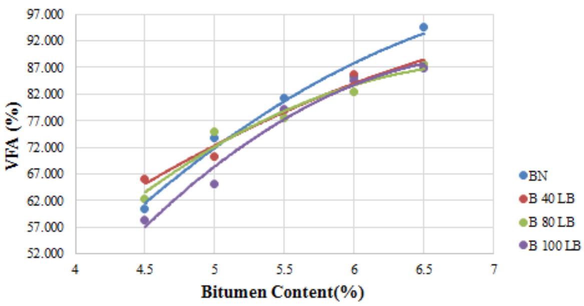

Figure 10 Value of Void Filled with Asphalt (VFA) asphalt mixture

The relationship between asphalt content and VFA for various levels of concrete waste is shown in Figure 10. VFA increases VFA with increasing asphalt content.

VFA is the percentage of cavity filled with asphalt in the mixture after compaction. The VFA value greatly affects the tightness of the mixture to water, air and the elasticity of the mixture. The VFA value in this study is still in accordance with the specifications used.

Table 6 Comparison of normal AC-WC asphalt mixture with modified AC-WC asphalt mixture

Parameter	AC-WC	AC-WC 100 LB + 0.25 % WET FIX
Density (gr/ml)	2.455	2.222
Stability	998.23	1322.617
Flow (mm)	3.311	3.883
VIM (%)	3.672	12.225
VFA (%)	77.519	49.731

From the graph above, it can be shown that from the two variations there is a difference in the value that occurs, namely the density decreases from normal compared to the additional wetfix-be, but in its stability there is a significant increase in the asphalt using wetfix-be. The flow on wetfix-be asphalt is higher because asphalt mixed with wetfix-be is slightly thinner than ordinary asphalt. The VIM value with wetfix-be asphalt is very large because it uses 100% coarse concrete waste aggregate, because the lack of concrete waste aggregate has a higher absorption capacity than ordinary aggregate. The VFA value of asphalt using wetfix-be is lower due to the same thing, namely concrete waste aggregate has a high absorption capacity.

Table 7 Immersion Index Results

Duration (Hour)	AC-WC 100 LB + 0.25 % WET FIX	AC-WC NORMAL
0.5	1322.617	998.23
24	1308.48	902.4
48	1218.24	752

Table 7 shows that by using the variation of immersion time for 30 minutes, 24 hours and 48 hours, the immersion index value in the AC-WC mixture of 100% concrete limb and the addition of 0.25% wetfix-be additives decreased but not too significant. Meanwhile, the normal AC-WC mixture has a significant reduction. This means that the use of wetfix-be additives is proven to minimize damage caused by water.

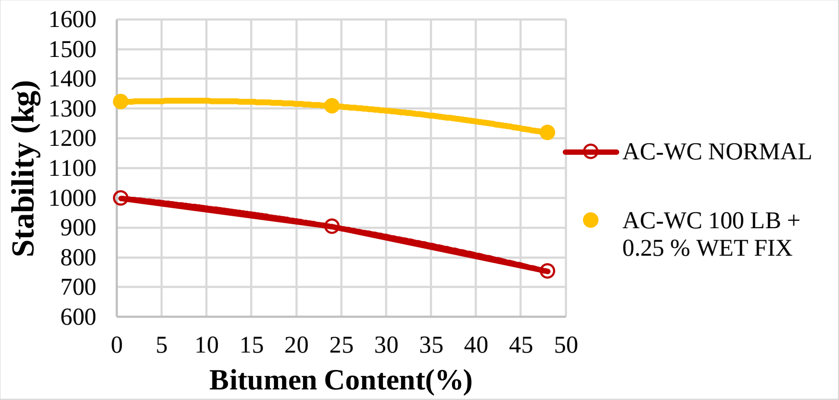

Figure 11 Graph of normal AC-WC relationship with Modified AC-WC

Figure 11 shows that of the two variations, both normal AC-WC and AC-WC using a wetfix-be, there is still a decrease in stability, but normal AC-WC, the decrease is more significant than that of AC-WC using a wetfix-be which is more sloping, This proves that the addition of the wetfix-be to the asphalt mixture can increase the durability of bitumen to water. If the pavement uses a wet-fix mixture, of course the pavement will be more resistant if the road is in a flood-prone area compared to conventional asphalt pavement.

5. CONCLUSION

Based on the results of research on the use of concrete waste as a substitute for coarse aggregate and wetfix-be additives on stability and durability of the AC-WC hot asphalt mixture using Pertamina Pen 60/70 asphalt, the Bandung State Polytechnic Laboratory can be taken as follows:

1. Composition of normal asphalt mixture using 100% natural aggregate and 0% concrete waste with an optimum asphalt content of 5.35%. A variation mixture that uses 100% concrete waste and 0% natural aggregate, with an optimum asphalt concrete waste content of 5.6%.
2. Marshall characteristics of all variations in the mixture of KAO conditions, namely for the normal AC-WC variation, the initial stability value is 998.23 kg, the flow value is 3,311 mm, the dencity value is 2.455 gr / ml then the modified AC-WC variation mixture using 100% concrete waste and 0.25% wetfix-be with a stability value of 1322,617 kg, a flow value of 3.883 mm, a dencity value of 2.222 gr / ml. So that the parameters of the stiffness, strength and flexibility numbers of all mixture variations meet the requirements of the 2018 General Bina Marga Specifications.

3. The level of resistance and durability of the mixture to the effects of water undergoes a series of immersion periods, at a duration of 30 minutes, 1 day (24 hours), and 2 days (48 hours). Based on the results of the analysis, the variation of the mixture of 100% concrete waste and the addition of 0.25% wetfix-be has good durability. This is due to the nature of the wetfix-be itself, which is to minimize the damage caused by water.

ACKNOWLEDGMENT

This work was supported by PT Enceha Pasific who have contributed by providing assistance with wetfix-be and PT Pioneer Beton which has contributed to the provision of concrete waste.

REFERENCES

[1] Spesifikasi Umum Kementerian Pekerjaan Umum tahun 2010.

[2] Prawiro, Bangun, et al. 2014. Pengaruh Penggunaan Limbah Beton Sebagai Agregat Kasar Pada Campuran Aspal Porus dengan Tambahan Gilsonite. Malang (ID): Universitas Brawijaya

[3] Susilowati, Anni. 2019. Variasi Suhu Pemadatan Pada Campuran Beton Aspal Menggunakan Bahan Tambah Anti Stripping. Construction and Material Journal, e-ISSN 2655-9625, Volume 1 No 1 Maret 2019.

[4] Susanto, Andriyas, 2016. Pengaruh Limbah Beton dan Marmer pada Campuran Aspal Porus dengan Bahan Tambah Gilsonite, Malang: Universitas Brawijaya.

[5] Abdul Kholiq, Taufiq Hidayatullah, Penggunaan Bahan Additive Wetfix-Be sebagai Bahan Tambah Lapis Permukaan AC-WC.

[6] Spesifikasi Umum Bina Marga tahun 2018.

[7] Miller JS, Uzan J, Witczak MW (1983) Modification Of The Asphalt Institute Bituminious Mix Modulus Predictive Equation (Discussion), ISBN: 0309035546.

[8] Institute A (1983) Asphalt Cold-Mix Recycling:Asphalt Institute.

[9] Misbah (2015) Pengaruh Variasi Kadar Aspal Terhadap Nilai Karakteristik Campuran Panas Aspal Agregat (AC-BC) dengan Pengujian Marshall, Juenal Teknik Sipil ITP: ISSN: 2354-8452