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The Effect of Addition RAP as Quality Improved for Hot Paved Mixtures

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ABSTRACT

Reclaimed Asphalt Pavement (RAP) is the residual waste of pavement that has been damaged or has reached the end of the pavement by using a Cold Milling Machine (CMM). The old aggregate undergoes gradation changes due to traffic loads and weather effects so the gradation is not following the ideal gradation plan. The addition of natural aggregates aims to improve the grading envelope to meet the upper and lower limits of the AC-BC layer requirements. This study aims to determine the optimal composition of the RAP material in terms of Marshall characteristics. The use of RAP material variations is 30%, 40%, and 50% of the total composition of the mixture. This study refers to the 2018 Bina Marga specifications and the Marshall method for laboratory testing. The research steps consisted of material extraction testing, aggregate and asphalt properties, sieve analysis tests for mixed grading envelopes, and Marshall tests.

The results of this study are the characteristics of the mixture in terms of Marshall stability for the composition of RAP 30%, the stability value is 1433.3 Kg, RAP 40% is 1621.7 Kg, and RAP 50% is 1920.8 Kg. The greater the composition of the RAP, the greater the stability value, which shows the strong mixed nature of holding vehicle traffic loads and is flexible in holding the deflection load so that bleeding does not occur.

Keywords : reclaimed asphalt pavement, natural aggregate, marshall, asphalt concrete-binder course, stability.

INTRODUCTION

Infrastructure Asset Management is about managing the infrastructure along its life cycle so that the infrastructure can be always capable to well execute its function, economically, efficiently, effectively, and always in line with the sustainability principle (Suprayitno & Soemitro, 2018). Infrastructure design is therefore capital. Nowadays, for road infrastructure, RAP utilization is considered beneficial, from the point of view of economics and sustainability. This is following IAM Basic Principle, in the planning and the design of the road network.

Hot asphalt mixture consists of coarse aggregate, fine aggregate, filler, and bitumen. Approximately 1.3 million tonnes of asphalt are required per year. The composition of the asphalt in the mixture is 5-10% of the total weight. For asphalt needs, apart from increasing prices from year to year, Indonesia is only able to produce 900,000 tons of asphalt per year. PT. Pertamina is only able to produce 600,000 tons per year while the rest is imported to meet the needs for road pavement production. RAP is the use of material from the old flexible pavement that has been damaged, which is then reused as a new asphalt mixture for road pavement repair. RAP material can be reused in new asphalt mixtures because the

components in the form of aggregate and asphalt still have value. The use of RAP for asphalt pavement has been carried out in the United States 40 European countries as many as 26 countries and Japan (Shen W, 2015). Green technology that has been implemented in Japan is based on five factors, namely; (a) minimizing the amount of asphalt pavement waste (b) saving natural resources (c) energy conservation (d) reducing carbon dioxide by saving energy production (e) reducing the cost of asphalt pavement (Pradhan S, 2015).

The addition of new aggregate and asphalt to the RAP mixture is a result of the deteriorating properties and characteristics of the two basic materials. Old aggregates due to traffic loads and the effects of weather will experience gradation changes due to breakage or wear so that the gradation is no longer following the original ideal gradation plan. The old asphalt also changes the form of aging (aging) due to chemical processes (solar ultraviolet rays, rain) and mechanical processes (traffic loads). As a result, the asphalt becomes dry, hard, and brittle. To reuse the old material, specifically for aggregate, it is necessary to add new fractions to complement the existing gradations with new ones that meet the gradient envelope of the AC-BC hot asphalt layer specifications (Suwantoro, 2010). This study aims to determine the effect of natural aggregate as a material to improve the composition of hot asphalt mixture with RAP in terms of Marshall characteristics. The use of RAP variations of 30%, 40%, and 50% of the total composition of the mixture is compared with the results of artificial aggregates and using 5% fly ash filler from previous studies (Widayanti et al., 2017).

MATERIALS

The material used in this study is reclaimed asphalt material (RAP) produced from excavation or dredging of cold milling machines (CMM) sourced from the East Java Waru National Park section of Waru National Park. Natural aggregate comes from Kejayen Pasuruan and is obtained from crushed stone from AMP PT. Merak Indo Driyorejo, Gresik. Pertamina asphalt binder with penetration type pen 60/70. The materials are illustrated in Figure 1 as follows.

Figure 1. Material for making AC-BC with RAP

The special bitumen content extraction test for RAP materials first used glass reflux tubes, aimed at restoring the material composition according to plan, and proceeded with testing the physical properties of asphalt to determine the asphalt properties over its service life. The chemical used for purification is pure trichloroethylene or pure methylene chloride solvent. The reference for this asphalt level extraction test is RSNI-05-2004 (Sunil et al, 2014). Penetration of 60/70 asphalt oil was tested for adhesion asphalt properties according to Bina Marga 2018 specifications. Testing for properties of natural aggregates and RAP aggregates included specific gravity testing, aggregate absorption, aggregate abrasion with a Los Angeles machine, aggregate adhesiveness to asphalt, and aggregate flake and deformity indexes. . Aims to determine whether the aggregate material can be used following the specifications to be used in the AC-BC concrete asphalt layer mixture.

Aggregate gradation is the distribution of aggregate particles based on their size which complements each other and forms interrelated bonds that can affect stability. The aggregate gradation is obtained from the results of inspection analysis using 1 set of filters. The largest filter size is placed at the top and the best No.200 at the bottom before the pan. Determine the asphalt content for the mix using the calculation formula from NAPA calculating the yield of the fraction that passes through the filter of the aggregate filter. The intermediate bitumen content obtained from the formula is rounded off to the nearest 0.5%. The variations used were 5 variations of the asphalt level, each 0.5% different. Determine the optimal bitumen content of the design, which is the bitumen content that takes into account the RAP extraction results and the emulsion asphalt residue content which results in maximum stability whose value is equal to or greater than the stability value according to the 2018 Bina Marga specifications.

METHOD

Preparation of asphalt or briquette concrete specimens are prepared in natural aggregate (virgin aggregate), reclaimed asphalt pavement (RAP), and Pen. 60/70 asphalt according to the number of specimens to be made. Prepare the mixture according to the combined gradation calculation for the asphalt concrete mix binder course (AC-BC) according to the specifications of Bina Marga 2018. In this study, there are several variations in the composition of the mixture from reclaimed additions. The stages of making Asphalt Concrete - Binder Course (AC-BC) according to Bina Marga 2018 specifications, namely. The four steps of using RAP are illustrated in Figure 2.

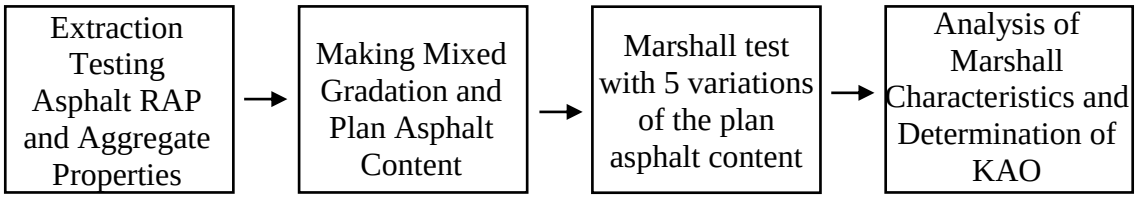

Figure 2. Steps for using Reclaimed Asphalt Pavement

Marshall test, the equipment used consists of a proving ring with a capacity of 22.2 KN (= 5000 lbf), a flow meter, a compactor, immersion hammer equipped with temperature control. The equipment is available at the Laboratory for Testing Materials Implementation of the VIII National Road Center in East Java and already has a standard calibration tool. The method used for the manufacture of asphalt concrete will follow the stages of applying the Marshall method (SNI-06-2489-1991 or AASTHO T 245-90, or ASTM D 1559-76). The nature of the hot recycled asphalt mixture must meet the requirements of the specific SKH-1.6.27 Bina Marga test object specification.

RESULT AND DISCUSSION

The results of the testing of the material properties of the research both from natural aggregate, penetration oil asphalt 60/70, and RAP materials refer to the requirements of the 2018 Bina Marga specification. **Table 1** shows that the conservation of the aggregate form after immersion in magnesium sulfate solution and the abrasion value that still meets the requirements does not exceed the limit. maximum, where the two values are indicators of aggregate resistance to degradation and disintegration during the production process and laying out the material in the field. The asphalt viscosity value also still meets the specifications so it is expected to be able to accept, absorb and withstand the thick asphalt film required. The test results of flat particles of natural aggregate have a higher value indicating that the RAP aggregate has an irregular surface because it has been exposed to

vehicle loads. The specific gravity test for RAP aggregates has a smaller value than for natural aggregates. Small density will have a large volume so with the same weight will require a lot of asphalt. The absorption value of the RAP aggregate is also greater because it has larger air pores than the smaller natural aggregate.

Table 1. Testing of RAP Aggregate Materials and Natural Aggregates

Aggregate Testing	RAP	Natural Aggregates	Specification
Abrasion (%)	25,96	27,26	Max. 40
Conservation of aggregate to sodium sulfate solution (%)	3,7	6,2	Max. 12
Asphalt adhesiveness (%)	> 95	> 95	Min. 95
Oval flat particles (%)	2	8	Max. 10
Specific gravity (%)	2,6	2,8	Min. 2,5
Absorption (%)	1,4	1,2	Max. 3%

Table 2 shows that the results of the RAP asphalt test, the initial planned penetration value of 60/70 decreased to 50 because the asphalt content in the RAP used was the result of dredging the old asphalt pavement layer that had been exposed to ultraviolet sunlight and passed by vehicle traffic loads so that the penetration value decreased. Testing the physical properties of RAP asphalt has increased viscosity and softening points, indicating that RAP asphalt has a level of asphalt hardness and stiffness at a certain temperature. The low penetration value and high viscosity and ductility values that do not meet the 2018 Bina Marga specifications indicate that RAP asphalt has a high level of hardness and stiffness. Increasing the hardness and stiffness of the asphalt can increase the stability of the mixture but on the other hand, it causes the mixture to be more brittle. After testing the RAP material as well as the new material following the specification requirements. The next step in this research is to test the sieve analysis of RAP aggregates and natural aggregates to be included in the grading envelope according to the requirements of the Bina Marga AC-BC hot layer of asphalt in 2018. Here is graph 4 of the sieve analysis for RAP aggregates, the percentage of 100% is entered into the envelope. gradation according to the requirements for the AC-BC layer.

Table 2. Testing of RAP Asphalt Materials and Asphalt Pen 60/70

Aspal Testing	RAP	Pen 60/70	Specification
Penetration at 25°C	50*	63	60-70
Viscosity at 135°C	1275	475	Min.300
Softening Point °C	57	49,2	Min.48
Ductility at 25°C	27,5*	>100	Min.100
Specific gravity (%)	1,03	1,03	Min.1,0
Extraction Asphalt Content (%)	4,7	-	-

*Noted: Asphalt penetration and ductility values do not meet the limits in the specifications

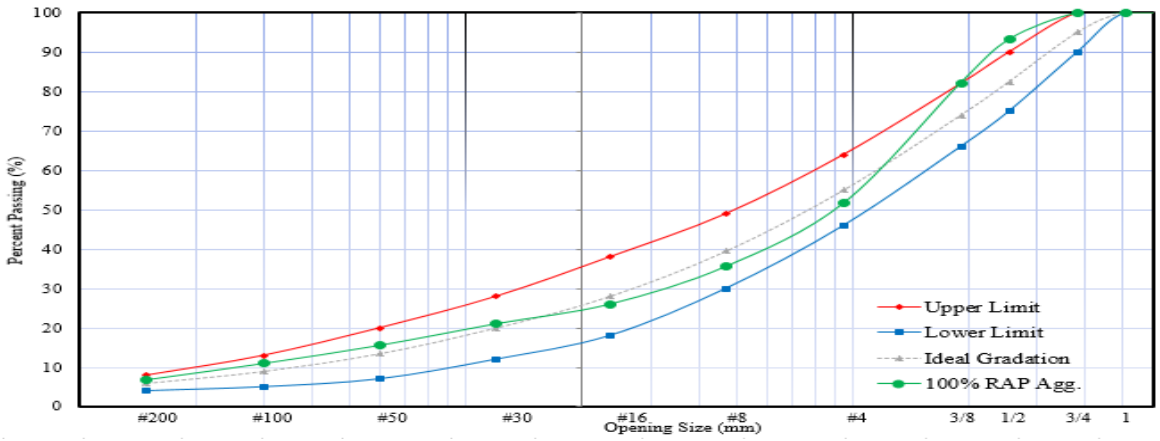

Figure 4. Mixed Gradation of 100% RAP

The results of **Figure 4** explain that the RAP aggregate sieve analysis is included in the upper and lower limit specifications for the AC-BC layer Bina Marga 2018. Figure 4 shows that for the filter size numbers 3/8, ½, and ¾ exceeding the specification limit, the RAP aggregate has a fraction. the size of the aggregate is too big for the AC-BC mixture so additional Natural aggregate is needed to improve the mixture grading envelope.

The Marshall test is an important step in determining the characteristics of the asphalt mixture. The characteristics of the asphalt mixture which are Marshall parameters are density, voids in mixed (VIM), voids in aggregate minerals (VMA), bitumen filled cavity (VFB), stability, plastic release (flow), Marshall Quotient, and durability. The following is a graph of the Marshall test results with variations in the addition of natural aggregates by 70%, 60%, and 50% regarding the Marshall test results.

Table 3. Results of the Marshall Test for AC-BC Layer

No	Mixed Properties	Unit	Method	Test Results			Specification
				50%	70%	60%	
1	Mixed Optimum Asphalt Levels	%		5,15	5,25	5,40	-
2	Density	Gr/cm^3	SNI 06-2489-1992	2,407	2,399	2,388	-
3	Void in the Mixed (VIM)	%	SNI 06-2489-1991	3,5	3,8	4,2	3-5
4	Void in Mineral Aggregate (VMA)	%	SNI 06-2489-1991	15,06	15,32	15,94	Min. 14
5	Void Filled with Bitumen (VFB)	%	SNI 06-2489-1991	76,74	75,22	73,39	Min. 65
6	Flow	Mm	SNI 06-2489-1991	3,27	3,20	3,10	2-4
7	Marshall Quotient	Kg/mm	SNI 06-2489-1991	589,63	509,9	465,8	200-400
8	Stability after immersion 1 x 30 minutes at 60 ° C	Kg	SNI 06-2489-1991	1920,83	1621,67	1433,33	Min.800
9	Marshall stability remains after soaking for 1x24 hours at 60 ° C	Kg	SNI 06-2489-1991	92,40	90,96	91,80	Min. 90

Based on **Table 3**, it is obtained that the volumetric characteristics (VIM / Void in Mix, VMA / Void Mineral Aggregate, and VFB / Void Fill Bitumen) show the results that meet the specifications, namely VIM of 3.5-4.2%, VMA of 15.06-15, 94%, VFB of 73.39-76.74%. Volumetric characteristics are factors that influence pavement durability (NAPA, 1996). VMA must provide sufficient space for VIM and VFB. The VIM value must be within a certain required range so that it is not too large, causing oxidation of asphalt, or too small so that there is not enough space for the asphalt flow due to traffic loading. The VFB value and the gradation determine the thickness of the asphalt film which affects the speed of asphalt oxidation and water absorption. The VIM and VMA values are inversely proportional to the density values achieved by the mixture. The higher the density of the mixture, the larger the cavity that is filled with asphalt or filler (VFB), thereby reducing the VIM and VMA values.

Stability is the maximum amount of load that can be achieved by the mixture which is stated in load units and is an indicator of the strength of the pavement layer in bearing traffic loads. Stability values for all mixtures can be achieved and meet standard specifications ranging from Marshall Stability of 1433.33-1920.83 kg. It also depends very much on the planned pavement layer including AC-BC, but the stability value that is too high is also not good because the properties of the pavement layer are very stiff and easy to crack (cracking). RAP is a layer that has expired its planned life so that the asphalt content becomes stiff.

The value of melt/flow is 3.10-3.27 mm. A high melt value indicates a plastic mixture. The factors that cause the plastic mixture to be estimated are high viscosity and low penetration. The viscosity of the RAP asphalt is greater and the penetration of RAP is smaller than the viscosity and penetration of asphalt which causes the higher the percentage of RAP, the more the flow/melting occurs.

CONCLUSION

Based on the analysis and discussion of the effect of adding natural aggregates to the RAP mixture, the following conclusions are obtained:

1. Natural Aggregate Material is used as a refinement of RAP material with a composition of 50%, 60%, and 70% after analysis it can meet the mixed grading envelope for the AC-BC layer according to Bina Marga 2018 specifications. Natural Aggregate can improve the grading fraction of RAP aggregates has been eroded by the traffic load during their lifetime.
2. The optimal asphalt content value in AC-BC hot asphalt mixture with 70% Natural Aggregate is 5.40%, 60% Natural Aggregate is 5.25%, and 50% Natural Aggregate is 5.15% indicating that the composition of the mixture in the material RAP still contains asphalt so the greater use of RAP can reduce the value of the optimal asphalt content.
3. Characteristics of the Marshall mixture for the greatest stability value is the composition of 50% Natural Aggregate, namely 1920.83 kg, while for 60% Natural Aggregate it is 1621.67 kg and for 70% Natural Aggregate is 1433.33 kg. This is because the RAP material has a very small ductility value, indicating that the asphalt contained has hardened so that the properties of the hot asphalt mixture become stiff. The greater the use of RAP, the higher the stability value, but it has a disadvantage in distributing the load, namely it is easy to crack.

REFERENCES

Bina Marga. (2010). *Spesifikasi Umum Bina Marga Tahun 2010 Revisi 3.* Direktorat Jenderal Bina Marga Kementrian Pekerjaan Umum. Jakarta.

Budianto, H. (2009). *Menuju Jalan yang Andal*. PT. Cakra Daya Sakti. Surabaya.

Departemen Pemukiman dan Prasarana Wilayah. (2002). *Manual Pekerjaan Campuran Beraspal Panas.* Direktorat Jenderal Prasarana Wilayah. Jakarta.

Falevi, R. (2012). Optimalisasi Penggunaan Reclaimed Asphalt Pavement (RAP) sebagai Bahan Campuran Beraspal Panas (Asphaltic Concrete) Tipe AC-Wearing Course (ACWC) Gradasi Halus dengan Menggunakan Aspal Pen 60-70 Variasi Abrasi Agregat Baru (Studi Kasus Jalan Nasional Pandaan – Malang). *Tesis Pasca Sarjana*. Institut Teknologi Sepuluh Nopember Surabaya.

Handayani, R. (2016). "Analisa Penggunaan Reclaimed Asphalt Pavement (RAP) sebagai Bahan Campuran Beraspal Panas Tipe Asphalt Concrete-Binder Course (ACBC) dengan Menggunakan Fly Ash (Studi Kasus Ruas Jalan Taman Waru)". *Tesis Pasca Sarjana.* Institut Teknologi Sepuluh Nopember Surabaya.

Herawati, N., Soemitro, R.A.A., Budianto, H. (2012). "Analisis Penentuan Komposisi Optimal Penggunaan Reclaimed Asphalt Pavement (RAP) sebagai Bahan Campuran Beraspal Panas (Asphaltic Concrete) Menggunakan Aspal Modifikasi (Studi Kasus Jalan Pilang – Probolinggo)". *Prosiding Seminar Nasional Aplikasi Teknologi Prasarana Wilayah (ATPW) Surabaya, 11 Juli 2012. ISSN 2301-6752, Material Bahan Bangunan dan Konstruksi, hal. F-1.*

Kusmarini, E.P., Soemitro, R.A.A., Budianto, H. (2012). "Analisis Penggunaan Reclaimed Asphalt Pavement (RAP) dan Aspal Pen 60 – 70 sebagai Bahan Campuran Beraspal Panas (Asphaltic Concrete) (Studi Kasus Ruas Jalan Gemekan – Jombang dan Pandaan – Malang)". *Prosiding Seminar Nasional Aplikasi Teknologi Prasarana Wilayah (ATPW) Surabaya, 11 Juli 2012, ISSN 2301-6752, Material Bahan Bangunan dan Konstruksi, hal. F-5 – F-10.*

NAPA (1996). *Hot Mix Asphalt Materials Mixture Design and Construction.* National Asphalt Pavement Association. Education Foundation. Maryland

Pradyumna, T Anil. Mittal, Abhishek, Jain, P.K. (2013). "Characterization of Reclaimed Asphalt Pavement (RAP) for Use in Bituminous Road Construction". *Procedia-Social and Behavioral Sciences 104, pp. 1149-1157.*

Shen, J., Amirkhanian, S., Aune, J.M. (2007). "Effects of Rejuvenation Agents of Superpave Mixtures Containing Reclaimed Asphalt Pavement". *Journal of Materials in Civil Engineering. ASCE. May. 2007.*

Sujiartono, A. (2014). Optimalisasi Penggunaan Reclaimed Asphalt Pavement (RAP) sebagai sebagai Bahan Campuran Beraspal Panas (Asphaltic Concrete) Tipe AC-Binder Course (AC-BC) dan AC-Base Course (AC-Base) dengan Menggunakan Aspal Modifikasi Asbuton (BNA-Blend) (Studi Kasus Jalan Nasional Pilang-Probolinggo). *Tesis Pasca Sarjana.* Institut Teknologi Sepuluh Nopember Surabaya.

Sukirman, S. (1995). *Perkerasan Lentur Jalan Raya. Penerbit Nova.* Bandung.

Suprayitno, H. & Soemitro, R.A.A. (2018). "Preliminary Reflexion on Basic Principle of Infrastructure Asset Management". *Jurnal Manajemen Aset Infrastruktur & Fasilitas – JMAIF 2(1) Maret 2018*

Suwantoro (2010). Optimalisasi Penggunaan Material Hasil Cold Milling untuk Daur Ulang Lapisan Perkerasan Beton Aspal Tipe AC (Asphaltic Concrete). *Tesis Pasca Sarjana.* Institut Teknologi Sepuluh Nopember Surabaya.

TRB (2011). A Manual for Design of Hot Mix Asphalt with Commentary. National Cooperative Highway Research Program. *NCHRP Report 673, Transportation Research Board.* Washington DC.

Wibowo, H.W. (2012). Optimalisasi Penggunaan Reclaimed Asphalt Pavement (RAP) sebagai Material Campuran pada Asphaltic Concrete Tipe AC–BC dan AC–Base dengan Pen 60-70 (Studi Kasus Jalan Nasional Pandaan – Malang). *Tesis Pasca Sarjana.* Institut Teknologi Sepuluh Nopember Surabaya.

Widayanti, A., Soemitro, R.A.A., Ekaputri, J.J., Suprayitno, H. (2013). "Karakteristik Material Pembentuk Reclaimed Asphalt dari Jalan Nasional di Provinsi Jawa Timur", *Jurnal Manajemen Aset Infrastruktur dan Fasilitas, Volume 1, No. 1, Desember 2017, ISSN 2615-1847, halaman 11-22.*

Widger, A., Skilnick, F., Zabolotnii, E. (2012). Utilization of Recycled Asphalt in Cold Mixes and Cold In-Place Recycling Processes-Guidelines. *Engineer-In-Training Clifton Associated Ltd.* Communities of Tomorrow. Leveraged Municipal Innovation Fund.

Xiao, F., Amirkhanian, S.N., Shen, J., Putman, B. (2009). "Influences of Crumb Rubber Size and Type on Reclaimed Asphalt Pavement (RAP) Mixtures". *Construction and Building Materials 23, hal.1028-1034.*

Xiao, F., Amirkhanian, Serji, J., Hsein, C. (2007). "Rutting Resistance of Rubberized Asphalt Concrete Pavements Containing Reclaimed Asphalt Pavement Mixtures". *Journal of Materials in Civil Engineering, ASCE, June 2007, pp. 475-483.*