Gradation Analysis of Reclaimed Asphalt Pavement from National Road as Asphalt Concrete Layer

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ABSTRAK

One of the assets of land transportation infrastructure that obtained attention now is the road. Road construction can support the developing economy, industry, trade, people and good mobility, regional development. Management of road infrastructure assets require to prioritize natural resources managements efficiently as possible. Reclaimed Asphalt Pavement (RAP) is the result of dredging material with aggregate gradation condition that are not in accordance with the needs of the gradation envelope. Utilization of RAP as a pavement layer is an effort to converse the use of natural materials. The efficiency aspect of RAP aggregate use needs to be done by determining the road pavement layer that is most appropriate to the condition of the RAP aggregate so that the addition of new aggregates is kept to a minimum. The aim of this study was to obtain a suitable pavement layer determination based on the aggregate gradation of RAP and standard specifications.

The method used literature study from previous research and RAP aggregate sieve analysis from national roads in East Java Province. The results showed that the utilization of RAP from national roads based on the RAP aggregate conformance value were AC-WC layer of 82.292%, AC-BC layer of 68.75% and AC-Base layer of 41.667%. Based on the gradation analysis, it is found that the RAP aggregate is best suited for the AC-WC layer, because it requires optimal RAP aggregate and the most efficient of additional aggregate.

Keywords : infrastructure asset management, pavement, road, gradation, reclaimed asphalt pavement.

INTRODUCTION

Road as one of the assets of land transportation infrastructure. Road construction that is currently involves adequate material availability. For the efficient use of natural materials, the use of environmental waste based materials needs to be optimized so that it can save on the use of natural materials, especially natural aggregates. Reclaimed Asphalt Pavement (RAP) is a result of scouring the road pavement with Cold Milling Machine, it can be done by milling or full depth removal. The large potential of RAP in East Java Province is around 50,000 m3/year, making this material increasingly piling up and its utilization needs to be increased again. Simples uses include the use of RAP for road shoulders, parking areas, entrances to residential and office location.

The extraction process is a process to separate RAP aggregate from RAP asphalt. From this process, the percentage of bitumen contained in RAP can be obtained, and sieve analysis separating RAP asphalt with it constituent substances. The aggregates consist of coarse, medium and fine fraction materials with sizes (10/20), (5/10), (0/5). The aggregate is a mixture of road pavement components with the largest percentage of 90-95% in weight percentage, 75-85% in volume percentages.

The utilization of RAP decrease the accumulation of RAP therefore it does not damage the environment, cost efficiency, reduce the use of natural resources, reduce the rate of damage caused by mining and quarrying (Budianto, 2009). The use of RAP increases volumetric, mechanical and properties of mixtures (Shen et al, 2007), affects the road technical life and damage resistance (Xiao et al, 2007), increases stability (Parvez et al, 2008), produce better workability and stability (Xiao et al, 2009). The use of RAP reduces the requirement to dispose of old road pavements, and preserves the availability of natural asphalt and aggregate. It has an impact on saving production costs and increasing profits for the community (TRB, 2011). The use of RAP is beneficial for environmental sustainability, it has the ability to produce optimum mixed performance (Widger et al, 2012), improve mixed performance (Pradyumma et al, 2013).

On the other hand the weakness of RAP is that the RAP gradation is not included in the standard gradation curve (Herawati, 2012; Kusmarini, 2012; Handayani, 2016), ductility is not in accordance with standards (Falevi, 2012; Herawati, 2012; Kusmarini, 2012; Wibowo, 2012; Harahab, 2013; Sujiartono, 2014), penetration is not in accordance with standards (Falevi, 2012; Herawati, 2012; Kusmarini, 2012; Wibowo, 2012; Harahab, 2013; Sujiartono, 2014; Handayani, 2016). The other studies stated the use of RAP increases brittleness of pavement mixtures (Parveez, 2008). In the pavement mixture, it does not produce consistency changes in the addition of physical properties mixtures in the aspect of penetration, ductility and softening point. In this case, the research support in microstructural aspects is required therefore it can improve the technical performance of pavement mixtures (Sunil et al, 2014).

In terms of utilizing RAP as a more efficient pavement material, a study of RAP aggregate grading from national roads in East Java and the selection of road pavement layers that are suitable for RAP gradation is required so that the potential utilization of RAP is more optimal and the demand for additional natural aggregates can be minimized.

LITERATURE REVIEW

Reclaimed Asphalt Pavement define as a result of dredging the pavement layer with Cold Milling Machine, it can be done by Milling or full depth removal (TRB, 2011).

HMA mixed planning containing RAP requires testing that is important to obtain the characteristics of RAP. To obtain an efficient design and produce a mixture with RAP. RAP properties are required as follows asphalt levels in RAP, RAP aggregate gradations, RAP specific gravity aggregate, RAP particle coarse aggregate particles, flaky and elongated particle of RAP coarse aggregate, angularity of RAP fine aggregate (TRB, 2011).

The extraction process is the process of separating aggregates and asphalt in RAP using an Extractor Solvent tool. The RAP recovery process is the process of separating the asphalt with its constituent substances.

The aggregate consists of coarse aggregate with a size of 10/20 mm, medium aggregate with a size of 5/10 mm and fine aggregate with a size of 0/5 mm. Aggregate gradation is a mixture of road pavement components with the largest percentages of 90-95% in weight percentages and 75-85% in volume percentages. Aggregate gradation is the aggregate grain size distribution expressed as a percent of total aggregate weight. The aggregate gradation is obtained by sieve analyzing from the aggregate filtering process with various sieve size. Gradation is likely to be important in aggregate properties. This will affect the properties of HMA, including stiffness, stability, durability, permeability, workability, fatigue resistance, friction resistance and resistance to damage. Therefore gradation is the main consideration in HMA/Hot Mix Asphalt planning. Aggregate gradations consist of uniform/open/uniformly graded, good graded/dense graded, gap graded (NAPA, 1996). Uniformly graded is a gradation with almost the same size aggregate, containing fine aggregates that are few in number therefore they can not fill the voids of aggregates. They will produce a layer of pavement with high permeability, low stability, small volume weight. Dense graded is gradation with a mixture of coarse and fine aggregates in a balanced proportion. It results in a high stability of road pavement layer, less waterproof, poor drainage, large volume weight. Gap graded is a gradation with an aggregate mixture with one fraction lost or very little fraction (Sukirman, 1995).

Asphalt Concrete is a continuous graded of asphalt concrete, for roads with heavy traffic. The most important characteristic is stability. Asphalt Concrete is divided into 3 layers, namely AC-WC (Asphalt Concrete – Wearing Coarse), AC-BC (Asphalt Concrete – Binder Coarse), AC-Base (Asphalt Concrete- Base). AC-WC or wearing layer with a minimum thickness of 4 mm, AC-BC or binder layer with a minimum thickness of 5 mm, AC-Base or foundation layer with a minimum thickness 6 mm (Sukirman, 2003). The combined aggregate gradation envelope for a mixture of Asphalt Concrete based on the Bina Marga Specification 2018 is presented in Table

Table 1. Gradation Envelope of Combined Aggregate in Asphalt Concrete

Sieve Size (mm)	**Sieve Size (inch)**	**Asphalt Concrete/AC**		
		Wearing Coarse/WC	**Binder Coarse/BC**	**Base Coarse**
37.5	1 1/2”	-	-	100
25	1”	-	100	90-100
19	¾”	100	90-100	76-90
12.5	½”	90-100	75-90	60-78
9.5	3/8”	77-90	66-82	52-71
4.75	4	53-69	46-64	35-54
2.36	8	33-53	30-49	23-41
1.18	16	21-40	18-38	13-30
0.6	30	14-30	12-28	10-22
0.3	50	9-22	7-20	6-15
0.15	#100	6-15	5-13	4-10
0.075	#200	4-9	4-8	3-7

Source: Bina Marga Specification (2018)

METHOD

The methods of collecting data used literature studies of previous research on RAP from national roads in East Java Province. The RAP material come from previous research and current research by sieve analyzing from Margomulyo - Surabaya, Waru - Taman Sidoarjo, Gemekan - Jombang, Pandaan - Malang, Pilang – Probolinggo locations.

RESULT AND DISCUSSION `

Based on the results of the RAP aggregate sieve analysis originating from several sources locations of RAP , the following results are presented in **Table 2, Table 3** and **Table 4**.

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Table 2. RAP Aggregate Gradation for Asphalt Concrete – Wearing Course

Lower	Upper	ZMS	WWT	HWT	KGJ	KPM	HPP	FPM	WPM	
		% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	Sieve
100	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1 1/2 "
100	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1 "
100	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	3/4 "
90	100	97.40	93.29	100.00	97.30	96.91	97.08	98.70	98.70	1/2 "
77	90	93.10	82.22	85.34	90.53	86.56	91.93	93.29	93.29	3/8
53	69	67.20	51.75	51.64	42.61	50.37	68.15	72.16	72.16	# 4
33	53.0	49.00	35.68	35.91	29.01	28.74	44.48	47.78	47.78	# 8
21	40.0	35.00	26.08	27.08	22.48	19.69	31.56	34.01	34.01	# 16
14	30.0	25.30	21.10	20.88	17.75	15.36	23.34	25.79	25.79	# 30
9	22.0	18.40	15.62	15.56	12.28	11.06	16.37	19.27	19.27	# 50
6	15	12.80	11.02	10.18	6.94	6.86	10.44	13.67	13.67	# 100
4	9	3.50	6.89	5.00	2.25	2.49	6.27	8.70	8.70	# 200
Conformity (%)		83.333	91.667	91.667	66.667	66.667	91.667	83.333	83.333	
Average (%)		82.292								

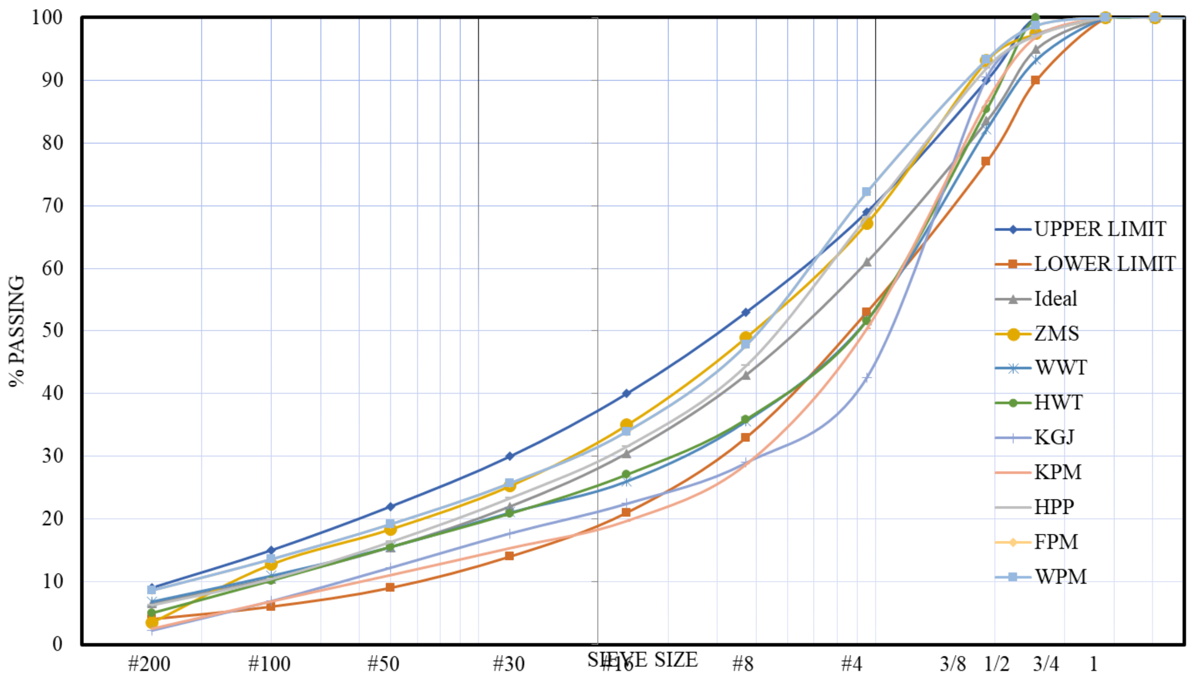

Figure 1. RAP Aggregate Gradation for Asphalt Concrete Wearing Course

Note:

ZMS : Zhain Margomulyo – Surabaya
WWT : Widayanti Waru – Taman
HWT : Handayani Waru – Taman
KGJ : Kusmarini Gemekan – Jombang
KPM : Kusmarini Pandaan - Malang
HPP : Herawati Pilang - Probolinggo
FPM : Falevi Pandaan - Malang
WPM : Wibowo Pandaan - Malang

Table 3. RAP Aggregate Gradation for Asphalt Concrete – Binder Coarse

Lower	Upper	ZMS % Passing	WWT % Passing	HWT % Passing	KGJ % Passing	KPM % Passing	HPP % Passing	FPM % Passing	WPM % Passing	Sieve
100	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1 1/2 "
100	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1 "
90	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	3/4 "
75	90	97.40	93.29	100.00	97.30	96.91	97.08	98.70	98.70	1/2 "
66	82	93.10	82.22	85.34	90.53	86.56	91.93	93.29	93.29	3/8
46	64	67.20	51.75	51.64	42.61	50.37	68.15	72.16	72.16	# 4
30	49.0	49.00	35.68	35.91	29.01	28.74	44.48	47.78	47.78	# 8
18	38.0	35.00	26.08	27.08	22.48	19.69	31.56	34.01	34.01	# 16
12	28.0	25.30	21.10	20.88	17.75	15.36	23.34	25.79	25.79	# 30
7	20.0	18.40	15.62	15.56	12.28	11.06	16.37	19.27	19.27	# 50
5	13	12.80	11.02	10.18	6.94	6.86	10.44	13.67	13.67	# 100
4	8	3.50	6.89	5.00	2.25	2.49	6.27	8.70	8.70	# 200
Conformity (%)		66.667	83.333	83.333	58.333	66.667	75.000	58.333	58.333	
Average (%)		68.750								

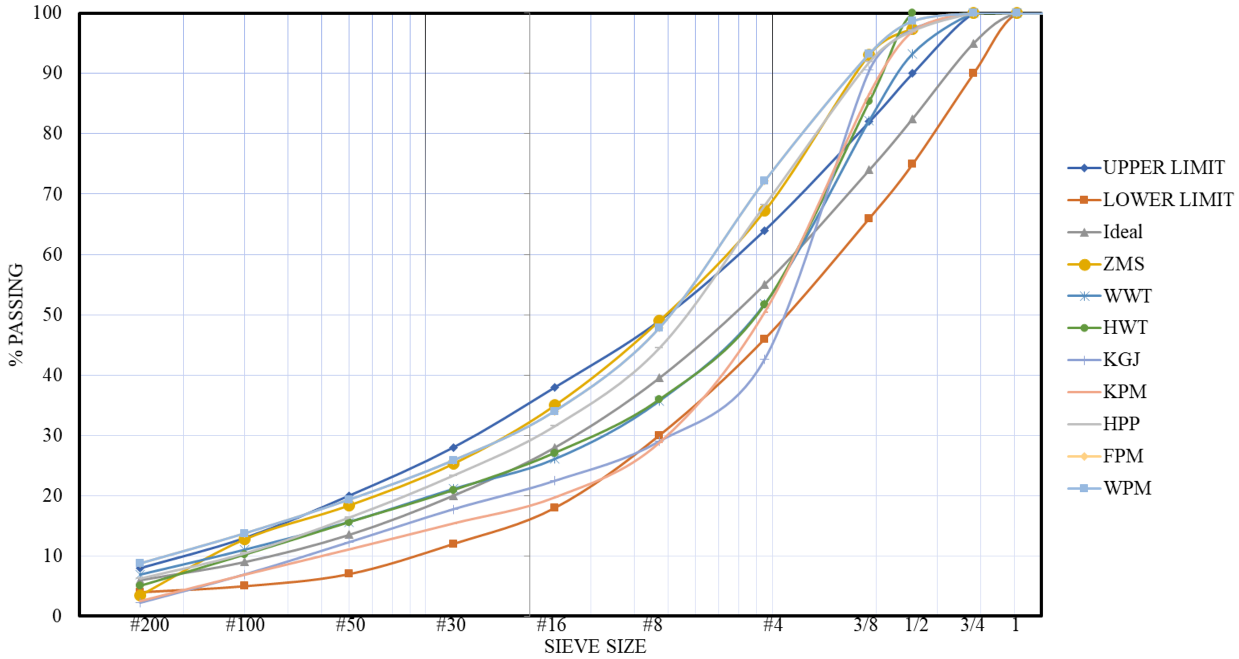

Figure 2. RAP Aggregate Gradation for Asphalt Concrete – Binder Coarse

Table 4. RAP Aggregate Gradation for Asphalt Concrete – Base Course

Lower	Upper	ZMS	WWT	HWT	KGJ	KPM	HPP	FPM	WPM	
		% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	Sieve
100	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1 1/2 "
90	100	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1 "
76	90	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	3/4 "
60	78	97.40	93.29	100.00	97.30	96.91	97.08	98.70	98.70	1/2 "
52	71	93.10	82.22	85.34	90.53	86.56	91.93	93.29	93.29	3/8
35	54	67.20	51.75	51.64	42.61	50.37	68.15	72.16	72.16	# 4
23	41.0	49.00	35.68	35.91	29.01	28.74	44.48	47.78	47.78	# 8
13	30.0	35.00	26.08	27.08	22.48	19.69	31.56	34.01	34.01	# 16
10	22.0	25.30	21.10	20.88	17.75	15.36	23.34	25.79	25.79	# 30
6	15.0	18.40	15.62	15.56	12.28	11.06	16.37	19.27	19.27	# 50
4	10	12.80	11.02	10.18	6.94	6.86	10.44	13.67	13.67	# 100
3	7	3.50	6.89	5.00	2.25	2.49	6.27	8.70	8.70	# 200
Conformity (%)		25.000	58.333	58.333	66.667	66.667	25.000	16.667	16.667	
Average (%)		41.667								

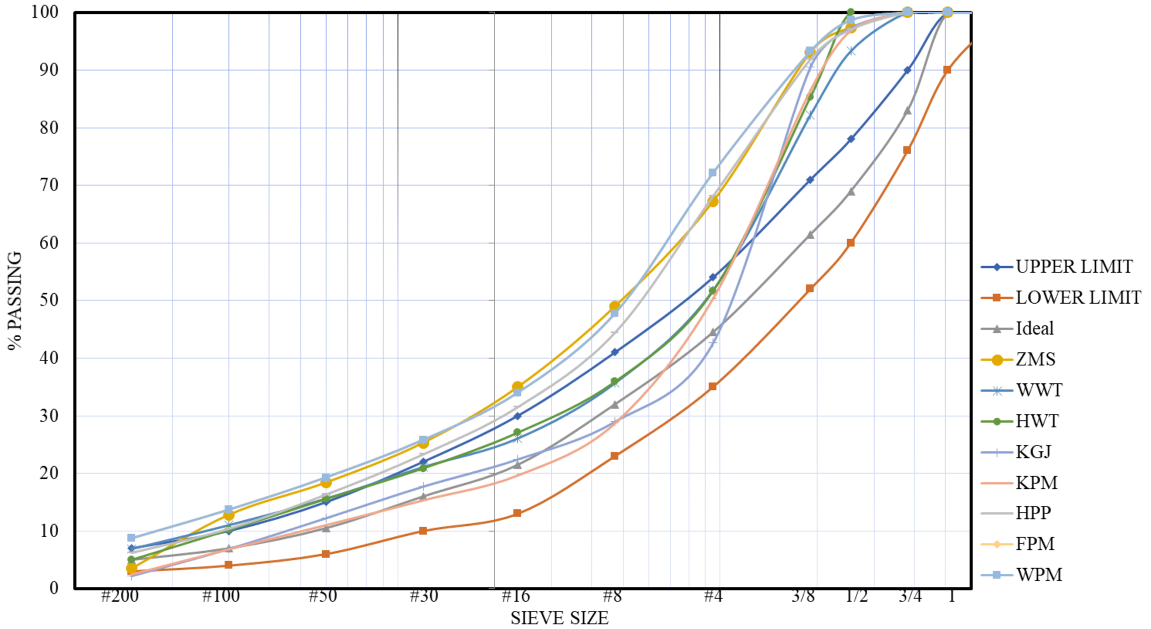

Figure 3. RAP Aggregate Gradation for Asphalt Concrete – Base Course

Based on the Table 2, Table 3, Table 4 and Figure 1, Figure 2 and Figure 3, it was found that the aggregate gradation of RAP originating from the National Road in East Java Province showed the highest suitability used for the AC-WC layer of 82.292%, the AC-BC layer of 68.750% and the AC-Base layer of 41.667%.

The aggregate gradation showed that many subtle sizes which require the most fine aggregates were for the AC-WC or surface layer. It was due to the fact that the aggregate RAP has experienced degradation and disintegration due to traffic loads, chemical effect due to the influence of weather (rain and heat), temperature and environment therefore its size does not match the previous condition.

The location of the RAP also determined the suitability of the use of the road pavement layer. In the AC-WC layer with suitability 91.667% was obtained from the RAP location from Waru-Taman, and Pilang-Probolinggo. It showed that many RAPs obtained in this location were smooth and suitable for the AC-WC layer. In the AC-BC layer with a suitability value of 83.333% obtained from the RAP Waru-Taman Sidoarjo. The RAP from Waru-Taman Sidoarjo location also matched the AC-BC layer. Whereas the AC-Base layer with 66.667%

conformity value was obtained from Gemekan-Jombang and Pandaan-Malang. It indicated that the Gemekan-Jombang and Pandaan Malang location were still found in large size materials and suitable for the Base –Coarse layer.

CONCLUSIONS

Based on the results of data collection, analysis and discussion, the conclusions obtained from this study are:

- Based on the size of the RAP aggregate, the RAP from national roads of East Java Province is best used for the AC-WC layer with a suitable value of 82.292%, AC-BC layer with a suitable value of 68.750% and AC-Base layer with a suitable value of 41.667%.
- The location of the origin of RAP also determines the suitability of the pavement layer.

Based on the conclusions above, two main recommendation that can be formulated as follows.

- Determination of the appropriate pavement layer also requires an analysis of the quality of RAP properties including the quality of asphalt and aggregate of RAP. In this case, because RAP is a residual material, the adjustments are for the AC-BC and AC-Base layer and not the AC-WC layer which is directly faced with loads, vehicle loads and traffic loads, as well as weather, temperature and rain effects on the pavement layer.
- The use of RAP must also consider the age of asphalt with the addition of additives and new asphalt, as well as new aggregates so as to obtain better asphalt performance.

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