PERFORMANCE OF SAND SHEET ASPHALT MIXTURE INCORPORATING RECLAIMED ASPHALT PAVEMENT

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Abstract

This paper presents lab works on sand sheet asphalt mixture utilizing reclaimed asphalt pavement (RAP) as the main material. Sand sheet asphalt mixture is dedicated for low to medium trafficked road pavement. The asphalt content of the RAP was initially extracted. A proportioned sand and rice husk ash was added to meet the aggregate grading. The asphalt used was AC 60/70, the most widely available type of asphalt in market. The asphalt content of the RAP was 6.7%. The mixture was produced in hot mix procedure with compaction of 2 x 50 Marshall Blow. The optimum asphalt content was 7.7% (including the asphalt content in the RAP). The properties of the samples were found well met the specification in Indonesia, i.e. the stability was 1501.5 kg, flow 2.96 mm, Marshall Quotient 476.31 kg/mm, VIM 4.916% , VFB 75.55%, VMA 20.10%, and retained stability 94%.

Keywords: performance, sand sheet, RAP, rice husk ash

Abstrak

Makalah ini mempresentasikan pekerjaan laboratorium *Sand Sheet Asphalt* dengan memanfaatkan perkerasan beraspal bekas (RAP) sebagai material utama. *Sand Sheet Asphalt* dapat digunakan untuk perkerasan jalan dengan arus lalulintas ringan hingga sedang. Langkah awalnya dengan melakukan ekstraksi *asphalt content* pada RAP. Kemudian secara proporsi pasir dan sekam ditambahkan untuk mendapatkan komposisi butiran agregat. Aspal yang digunakan adalah AC 60/70 yang pada umumnya tersedia di pasaran. Kandungan aspal pada RAP sebesar 6,7%. Campuran dihasilkan dengan prosedur campuran beraspal panas dengan pemadatan 2 x 50 *Marshall blows*. Sedangkan kandungan optimal aspal sebesar 7,7% (termasuk kadar aspal dalam RAP). Properti sampel ditemukan memenuhi spesifikasi yang berlaku di Indonesia, yaitu stabilitas 1501,5 kg, *flow* 2,96 mm, Marshall Quotient 476,31 kh/mm, VIM 4,916%, VFB 75,55%, VMA 20,10%, dan stabilitas sisa 94%.

Kata-kata kunci: kekuatan, sand sheet, perkerasan aspal bekas, sekam.

INTRODUCTION

Recycling of asphalt mixture for road pavement is essential in order to reduce demand of natural aggregates. Exploration of virgin aggregates can damage the environment; therefore effort to utilize more sustainable materials for road construction needs to be promoted more widely.

Recycling of old road pavement which is often called reclaimed asphalt pavement (RAP), has been done since several years ago in developed countries. The recycling of RAP has been encouraged by the commitment of the governments to support more sustainable road construction. This matter needs to be addressed further in developing countries, where usually commitment towards greener technology has not yet been properly implemented. There is also no recycling target available as part of the government policy. More often considerations are based on economic cost of the construction with less consideration on aspect of sustainability.

Proper RAP recycling may include significant portion of theoretical aspects, which is implemented based on previous research results. Theoretically, the RAP should be managed properly, where it should be stocked based on its mixture type in order obtain more homogeneous materials (ARRA, 2001). As asphalt in old road pavement may harden, a suitable rejuvenator is needed (Bullin et al, 1997 and Roberts et al., 1996). It is also needed to determine the viscosity of the asphalt used which combined with the viscosity of the existing and the added asphalt. Theoretical applicationin utilizing RAP may be uneasily implemented in developing countries.

Incorporation of high RAP content into the mixture had been found to cause weaker performance of the mixture (HM, 2006 and WSDoT, 2007). However if the mixture will be used as pavement of lightly trafficked road, it can be suitable.

This paper describes experiment on the potential of RAP recycling in a simple way, where modification aggregate grading was done and without incorporating additive materials. Sand sheet asphalt mixture aggregate grading was targeted as the recycled mixture. This mixture is commonly used for pavement of lightly trafficked road. The old RAP was extracted to obtain its asphalt content. Asphalt penetration of 60/70 was added in various portions then the properties of the sand sheet mixture were evaluated.

MATERIALS AND METHOD

The reclaimed asphalt pavement (RAP) was taken from a road section at Ida Bagus Mantra Street (Sun Rise Road) in Bali. The aged of the road pavement was about 2 years before it was scrapped. The type of mixture and the penetration value of asphalt within the old asphalt pavement were unknown. The RAP was extracted and the asphalt content was 6,7% (Thanaya et al., 2013).

Materials Used And Its Properties

For modifying the aggregate grading, certain amount of natural fine aggregate was added in order to meet sand sheet aggregate grading. The aggregate gradation of the RAP, the gradation specification, and the target gradation are shown in Figure 1. The added fine aggregate was taken from a quarry at Apet Village, Klungkung Regency, Bali. Rice husk ash was added as filler material. The properties of the aggregate used are shown in Table 1 and the properties of the asphalt is given in Table 2. The materials and mixture were tested in line with the Indonesian National Standards.

It was intended to use more RAP into the total mixture, but should meet Sand Sheet Type B gradation specification which is slightly coarser than type A (DPWRI, 2010). After trials, it was found that when only fine aggregate added into the RAP, the RAP used can be up to 65%. When some coarser particles added, the amount of RAP can be included was less than 50%. It was decided just to add fine aggregates into the mixture, so more RAP can be included (see Table 3). Additionally, the mixture is addressed to accommodate light traffic. The consequence of just adding fine aggregates, referring to Figure 1, at particle size of 4.75 the gradation close to the lower limit, but still met the specification. The properties of the aggregates and asphalt used are shown in Tables 1 and 2.

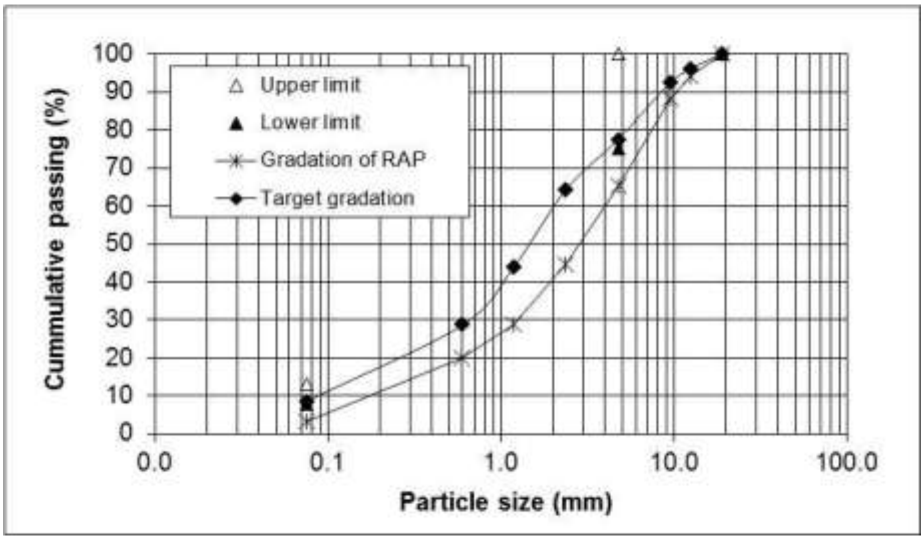

Figure 1 The Aggregate Grading of the RAP and the Sand Sheet Grading Specification

Table 1 Properties of the Aggregates

Materials	Properties					
	SG Bulk	SG SSD	SG App	Abs (%)	Sand Eq (%)	Abrasion (%)
Coarse aggregate of the RAP	2,079	2,101	2,126	2.245	-	-
Fine (natural) aggregate (< 2.36 mm)	2,485	2,520	2,580	1.525	76.52	-
Rice husk ash	1.82					

Table 2 Theproperties of The Asphalt Pen 60/70

Test	Results	Spec.
Penetration	67,8	60 - 70
Lash point	325°C	≥ 232°C
Softening point	57,5°C	≥ 48°C
SG	1,003	≥ 1,0 gr/ml
Ductility	127 cm	Min. 100 cm
Loss on heating	0,36 %	Max. 0,8 %

Method for Proportioning Materials

In order to meet the sand sheet aggregate grading for producing 1 sample with its standard size (approx. 1 inch diameter and 63.5 mm height), in order to maximize the use of RAP, 700 gram of RAP was used and added with 380 grams of natural fine aggregates (passing 2.36 mm, including rice husk ash as filer). The calculation table is given in Table 3.

Referring to the cumulative passing of the targeted grading as shown in Table 3, the coarse aggregate (retained 2.36 mm) was = (100-64.17)% = 35.83%. The fine aggregate (passing 2.36, retain on 0.075 mm) = (64.17-8.57)%= 55.60%, and the filler (passing 0.075 mm) was 8.57%.

The asphalt content was estimated based of an empirical formula as below (DPWI, 2002):

$$Pb = 0.035\ (\%\ \text{coarse agg}) + 0.045\ (\%\ \text{fine agg}) + 018\ (\%\ \text{filler}) + k \quad (1)$$

Where Pb is the estimated required asphalt content. The contant k was taken 2 (commonly used for hot rolled sheet mixture), as an initial approach (DPWI, 2004). The percentage of the coarse and fine aggregates was based on the targeted sand sheet aggregate grading as shown in Figure 1 and Table 3. The Pb has been calculated as below.

$$Pb = 0.035\ (35.87) + 0.045\ (55.6) + 0.18\ (8.57) + 2 = 7.2\ \%$$

The proportion of the mixture and added asphalt are calculated as shown in Table 4 (Wirahadi, 2011). The RAP and aggregate materials that had been proportioned then heated and added the require melted asphalt, and compacted by using Marshall hammer compactor for 2 x 50 blows.

Table 3 Tabulation of Aggregate Grading Modification to Meet Sand Sheet Specification

Sieves		Sand Sheet Spec.		RAP			Modification of Aggregate Gradation			
No.	Opening (mm)	Lower limit	Upper limit	Agg grad (%) cum passing	Retain	700	Addition (by trial)	Retain on Each Sieve		Cummulative Passing (to meet spec)
					(%)	(gram)	(gram)	(gram)	(%)	
a	b	c	d	e	f	g=700xg/100	h	i=g+h	j	k (%)
3/4"	19.0	100	100	100	0	0	0	0	0.00	100.00
1/2"	12.5			94.06	5.94	41.58	0	41.58	3.85	96.15
3/8"	9.5			88.33	5.73	40.11	0	40.11	3.71	92.44
No. 4	4.75	75	100	65.34	22.99	160.93	0	160.93	14.90	77.54
No. 8	2.36			44.72	20.62	144.34	0	144.34	13.36	64.17
No.16	1.18			29	15.72	110.04	110	220.04	20.37	43.80
No. 30	0.60			20	9	63	100	163	15.09	28.70
No. 200	0.075	8	13	3.22	16.78	117.46	100	217.46	20.14	8.57
Pan					3.22	22.54	70	92.54	8.57	
				Total	100	700	380	1080	100	
				Percentage to total		65%	35%		100%	

Table 4 The Proportion of The Mixture With Variation of Added Asphalt Content

Target Total Asphalt Content	RAP Weight	Weight of Added Aggregate	Weight of Agg + RAP	RAP Asphalt Content	Asphalt Weight of RAP	Trial of Added Asphalt		Total Weight	Final Asphalt Content
	a	b	c=a+b	d	e=(axd)/100	f=added asphalt	g=added asphalt	h=c+g	i={(e+g)/h} x100%
(%)	(gram)	(gram)	(gram)	(%)	(gram)	(%)	(gram)	(gram)	(%)
5.70	700	380	1,080	6.7	46.9	1.44	15.5	1,095.5	5.70
6.20	700	380	1,080	6.7	46.9	1.98	21.3	1,101.3	6.20
6.70	700	380	1,080	6.7	46.9	2.527	27.2	1,107.2	6.70
7.20	700	380	1,080	6.7	46.9	3.08	33.2	1,113.2	7.20
7.70	700	380	1,080	6.7	46.9	3.64	39.3	1,119.3	7.70
8.20	700	380	1,080	6.7	46.9	4.2	45.3	1,125.3	8.20
8.70	700	380	1,080	6.7	46.9	4.77	51.5	1,131.5	8.70

RESULTS AND DISCUSSION

The properties of the sand sheet asphalt mixture incorporating RAP are shown in Figures 2 to 7. The summary of the properties of the mixture are shown in Table 5.

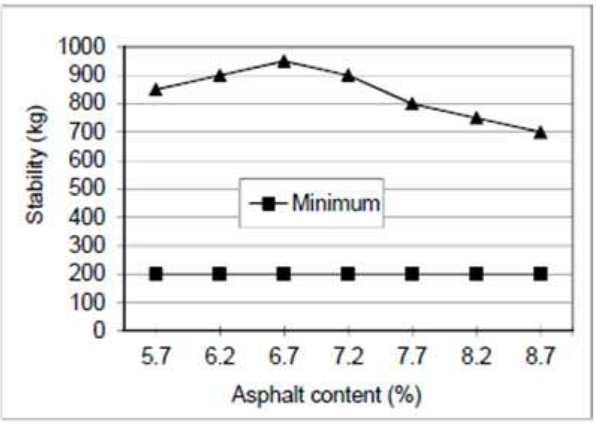

Figure 2 Stability vs Asphalt Content

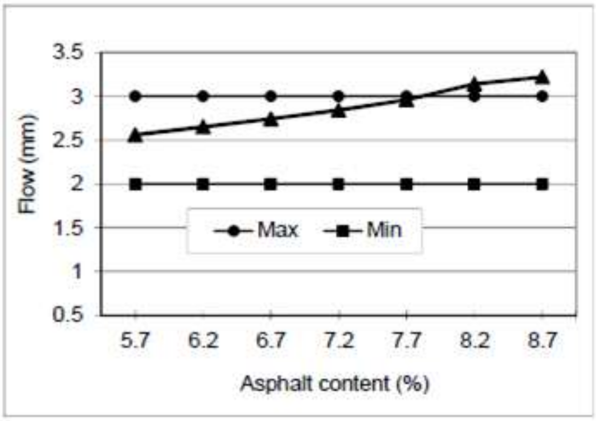

Figure 3 Flow vs Asphalt Content

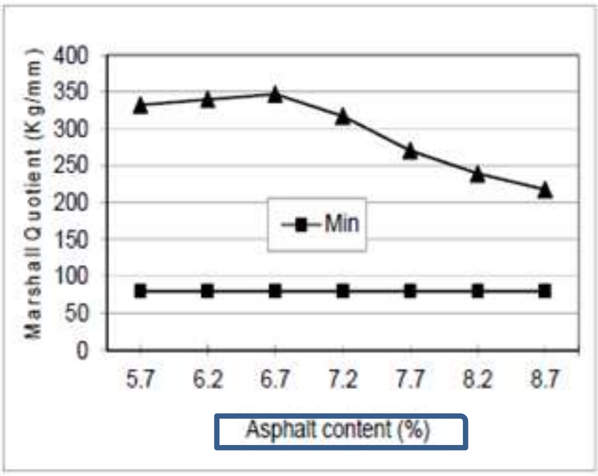

Figure 4 MQ vs Asphalt Content

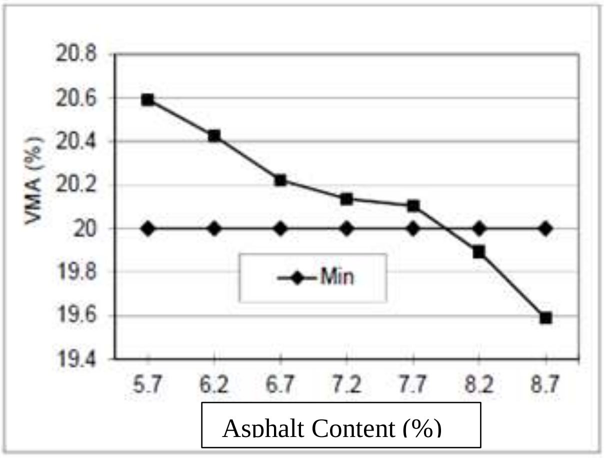

Figure 5 VMA vs Asphalt Content

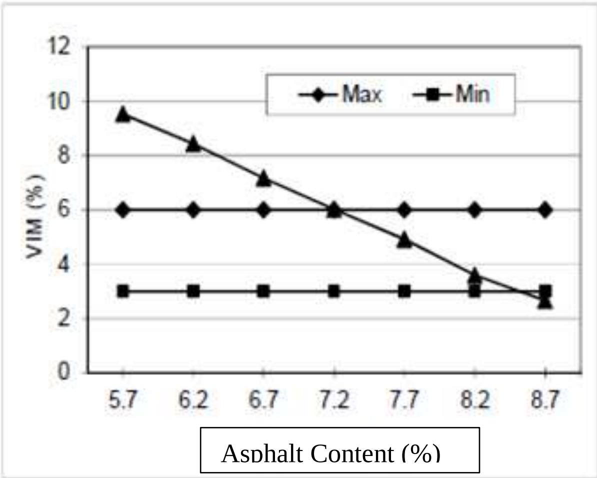

Figure 6 VIMvs Asphalt Content

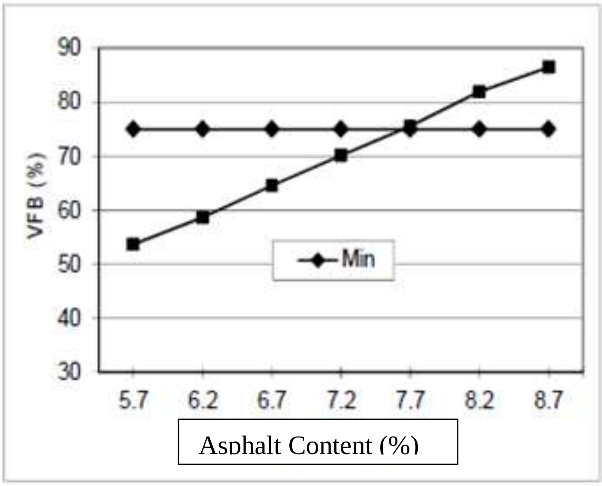

Figure 7 VFB vs Asphalt Content

Referring to Figure 2 and Figure 4, it is shown that the stability and the Marshall Quotient are well above the minimum value. Meanwhile at Figures 3, 5, 6, and 7 show that the properties of the mixture meet the specification at certain range of asphalt content. These are common in asphalt mixture. Considering the results plotted in Figure 8 and the data shown in Table 5, the optimum asphalt content is limited by the flow, VIM and VMA. Hence the optimum was taken at 7.7% total asphalt content (3.64% of added asphalt, as shown in Table 4).

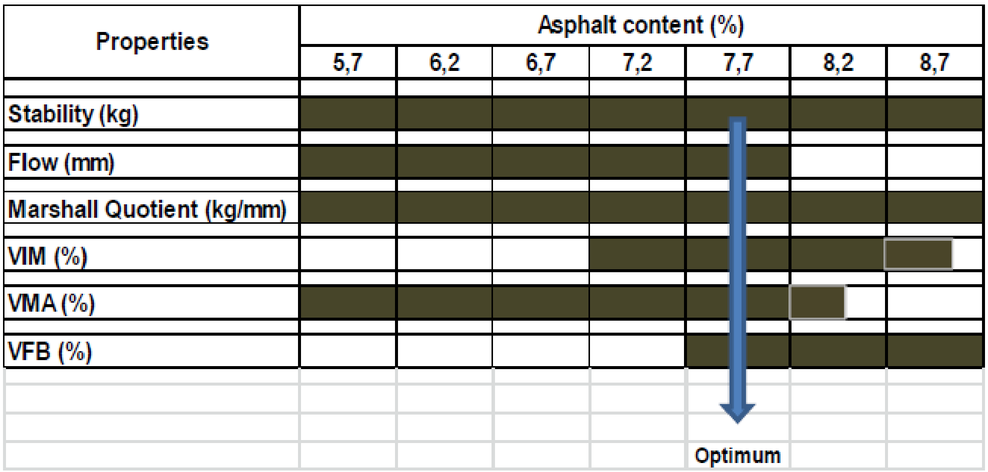

Figure 8 Determination of Optimum Asphalt Content (Total Asphalt Content)

In general, the above results and discussion show that incorporation of RAP up to 65% by weight of the total RAP and added aggregate which include rice husk ash as filler material, can meet the specified properties of sand sheet asphalt mixture. The stability obtained by applying 2 x 50 Marshall blows in producing samples and the Marshall Quotient gave far higher than the specified minimum value.

Table 5 Summary of The Properties of Sand Sheet Asphalt Mixture at Various Asphalt Content

Properties of Sand Sheet Asphat Mixture	Asphalt Content (%)							Specification
	5.7	6.2	6.7	7.2	7.7	8.2	8.7	
Stability (kg)	1,281.4	1,402.9	1,624.9	800.28	1,501.8	1,391.4	1,357.5	≥200
Flow (mm)	2.56	2.65	2.74	2.84	2.96	3.14	3.22	2-3
Marshall Quotient (kg/mm)	464.60	481.09	552.17	270.35	476.31	441.35	432.48	≥80
VIM (%)	9.528	8.445	7.171	5.85	4.916	3.591	2.661	3-6
VMA (%)	20.59	20.34	20.22	20.14	20.10	19.89	19.59	≥20
VFB (%)	53.72	58.66	64.54	75.11	75.55	81.95	86.42	≥75
Retained stab after 24 hours immersion at 60° (%)				94%				Min 90%

Wider use of RAP and waste materials for constructing road pavement need to be promoted as it can reduce large demand of natural aggregates. For pavement of lightly trafficked road, it is shown the high potential of RAP as the main materials. However further trials is needed in order to improve the flow, VIM, VMA and VFB. If applied for heavier trafficked road pavement, reduction of RAP incorporated is necessary.

CONCLUSION

From the results and discussion above, it can be concluded that:

1. Incorporation of RAP up to 65% by weight of the total RAP and added aggregate, can meet the specified properties of sand sheet asphalt mixture.
2. Rice husk ash is a potential material used as filler in asphalt mixture.

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