Marshall Test Comparison of Asphalt Mix PG 70 and Asphalt Pen 60/70 Based on Bina Marga General Specification

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ABSTRACT

Marshall aims to determine the characteristics of the dough in the test object. In this case to know the values of durability (stability), melting (flow), & marshall Qouintient. The Marshall tool is a pressure sensor that is equipped with a proving ring with a capacity of 22.5 KN or 5000 IBS. The proving ring is equipped with a measuring watch, which is useful for measuring the stability of the dough. Apart from that, there is still a flow meter to measure plastic melting, because the basic principle of the Marshall method is inspection of stability & melting (flow), and analysis of density and, pores based on the dough that is formed. The dough design of the Marshall method was discovered by Bruce Marshall, & has been standardized by ASTM or AASHTO through several modifications, namely ASTM D 1559-76, or 27 AASHTO T T-245-90. The standard Marshall Test object is a cylinder with a diameter of 4 inches (10,16cm) and a height of 2.5 inches (6,35cm).

Keywords: Marshall; flow; stability; ASTM; AASHTO.

INTRODUCTION

The development of road infrastructure in Indonesia is highly dependent on the quality of the pavement materials used, especially asphalt as a binder in asphalt mixtures. Two types of asphalt commonly used in Indonesia are PG (Performance Grade) 70 asphalt and Pen 60/70 asphalt, which have different characteristics according to the general specifications issued by Bina Marga [1]. PG 70 asphalt is a type of modified asphalt developed to improve asphalt performance in extreme environmental conditions, while Pen 60/70 asphalt is a standard oil asphalt that is widely used in road construction projects [2].

The development and construction of Indonesian highways are required to improve the level of safety, comfort and friendliness to the urban environment. For this reason, the use of polymer asphalt (PG 70) has been developed. To overcome these problems, many developments have been made related to asphalt technology, one of which is Performance Grade (PG) based modified asphalt. So that it is necessary to deepen and further understand the understanding, specifications, methods and handling related to these materials so that when applying in the field, maximum results are obtained and the condition of the road can be maintained so that it continues to function in serving traffic so that traffic safety is guaranteed and road services are improved.

PG 70 modified asphalt is a technology used to improve the performance of an asphalt mixture made by mixing asphalt with an additive [3]. PG 70 asphalt is specially formulated for use as a binder in highway construction, especially on roads with heavy traffic and heavy vehicle loads. PG 70 asphalt has better performance in terms of durability, stability, and flexibility than oil asphalt [2]. To overcome these problems, many developments have been made related to asphalt technology, one of which is Performance Grade (PG) based modified asphalt. So that further deepening and understanding is needed regarding the understanding, specifications, methods and handling related to these materials so that when applying in the field maximum results are obtained and the condition of the road can be maintained so that it continues to function in serving traffic so that traffic safety is guaranteed and road services are improved.

Marshall Test is one of the testing methods used to evaluate the quality of asphalt mixtures based on stability, flow, and Marshall Quotient values. This research compares the performance of PG 70

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and Pen 60/70 asphalt mixtures based on Bina Marga General Specifications, with a focus on evaluating the stability and durability of these asphalt mixtures. The results of this research are expected to provide deeper insights into the performance of both types of asphalt in meeting pavement standards in Indonesia, as well as help policy makers and civil engineering practitioners in determining the optimal choice of materials [1], [4], [5].

In Bina-Marga, road pavement, there are two main types: flexible pavement and rigid pavement. Flexible pavement consists of several layers, starting from the surface course, the base course, the subbase course, and the subgrade [7], [8]. The surface layer usually uses an asphalt mixture designed to be resistant to wear and weather, as well as to provide driving comfort. The top and subbase layers function to distribute the load so that it does not directly press on the subgrade. Meanwhile, the subgrade itself must have sufficient bearing capacity, and if it does not, it requires improvement by stabilizing the soil or adding certain materials. Meanwhile, rigid pavement uses Portland cement concrete slabs as the main layer, with or without reinforcement, which directly transfers vehicle loads to the subgrade [9], [10]. The concrete in rigid pavement has high strength so it can withstand heavy traffic loads with relatively little deformation. The choice between flexible pavement and rigid pavement in Bina Marga methods is usually determined based on technical aspects, costs, and local environmental conditions. The Bina-Marga, road pavement method also emphasizes a design process based on planned traffic analysis [11], [12]. The number of equivalent commercial vehicle passes (LHR or ESA) within the road's design life span is used as the basis for determining pavement thickness. Furthermore, testing the subgrade's bearing capacity using the California Bearing Ratio (CBR) parameter is crucial, as it directly influences the thickness of the layer to be installed [13]. Therefore, the lower the CBR value of the subgrade, the thicker the pavement layer required to optimally support vehicle loads. In addition to the thickness design, drainage aspects are also a concern, as water is one of the main factors causing road damage. Therefore, the Bina Marga method requires a good surface and subsurface drainage system, so that the road layer is not saturated with water and maintains its strength [14], [15].

RESEARCH METHODS

Research Design

This research uses an experimental method with the aim of comparing Marshall Test results on PG 70 asphalt mixtures and Pen 60/70 asphalt based on Bina Marga General Specifications. Tests were conducted on both types of asphalt to determine the performance characteristics of asphalt mixtures, including stability, flow, density, and Marshall Quotient.

Samples and Materials

The samples used in this study consisted of two types of asphalt mixtures, namely:

1. 1.PG 70 asphalt: A polymer modified asphalt designed for extreme environmental conditions.
2. 2.Pen 60/70 asphalt: Conventional oil asphalt that is widely used in road projects in Indonesia.

Data Analysis

The data obtained from the test results will be statistically analyzed to compare the performance of PG 70 and Pen 60/70 asphalt mixtures. Comparison of stability, flow, VMA, VIM, VFB and Marshall Quotient values will be used as a basis for evaluating the quality of both types of asphalt mixtures. Data analysis was carried out by reviewing the parameters of marshall testing on several test materials with different types of asphalt from marshall characteristics such as VMA, VIM, VFB, Stability and flow values. Furthermore, the analysis was carried out by making a comparison table of values and averages of marshall parameters, flow, and marshall quotient to see whether the use of PG 70 polymer modified asphalt showed better results than the use of Pen 70/70 oil asphalt in asphalt mixtures. The hope of this data analysis is that the use of PG 70 polymer modified asphalt in PG 70 asphalt mixtures in asphalt concrete can show better quality than the use of similar types of asphalt such as pen 60/70 oil asphalt so that it can be applied to the manufacture of asphalt in road works.

RESULT AND DISCUSSION

The asphalt mixture used in this research is AC-WC (Asphalt Concrete Wearing Course) with JMD (Job Mix Design) 6% asphalt content for each type of asphalt mixture.

Asphalt mixture materials were taken from AMP and then molded, compacted 2x75 times and soaked for 30 minutes and 24 hours at 60oC. Then the test specimens were weighed dry, in water and SSD to determine their specific gravity. In this test, the marshall characteristics reviewed are stability, flow, and marshall quotient. The marshall characteristics are used as a reference in determining the quality of asphalt against its stiffness level.

VMA (Void Mineral Agregate)

VMA is the percent of voids to aggregate and is expressed as an integer. VMA and VIM are indicators of durability.

Table 1. VMA Value

Test Piece	VMA	
	Asphalt PG 70	**Asphalt Pen 60/70**
After Soaking 1x30 minutes at 60ºC		
1	15,63	14,20
After Soaking 1x24 hours at 60ºC		
1	16,83	17,01

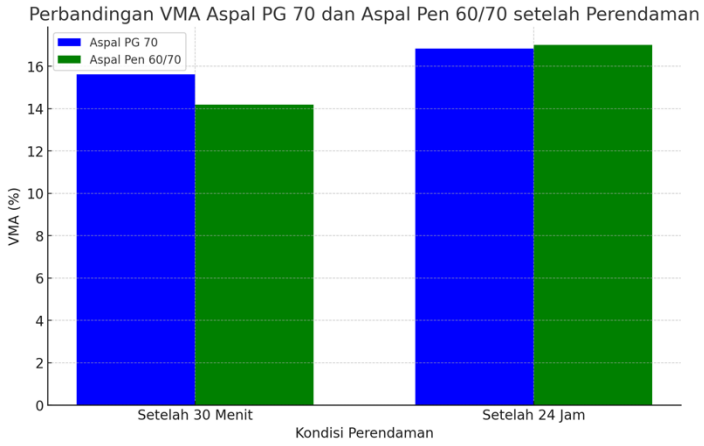

Figure 1. Comparison of VMA of PG 70 Asphalt and Pen 60/70 Asphalt after Soaking

Based on Table 1, the VMA value of both pen 60/70 asphalt and PG 70 asphalt increases after 1x24 hours of soaking at 60oC. The VMA value is the air voids of solid asphalt aggregate grains, including air voids and effective asphalt content, which is expressed in percent by volume, the quantity of air voids affects the performance of a mixture because if the VMA is too small, the mixture can experience durability problems and if the VMA is too large, the mixture can show stability problems and is not stable economical to produce. Based on the 2018 bina marga specifications required at least 14%, so from the test results above, the VIM value on pen 60/70 asphalt and PG 70 asphalt is declared eligible.

VIM (Void in Mix)

VIM (*Void in Mix*) is the voids contained in a mixture. The VIM value affects the durability of the pavement layer, the higher the value produced, the larger the voids in the mixture, so that the mixture can be porous.

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Table 2. VIM Value

Test Piece	VIM	
	Asphalt PG 70	**Asphalt Pen 60/70**
After Soaking 1x30 minutes at 60ºC		
1	2,92	2,76
After Soaking 1x24 hours at 60ºC		
1	4,05	5,94

Based on Table 2, it is known that the VIM value increases for both Pen 60/70 asphalt and PG 70 asphalt, after a 1x24 hour soaking at 60oC. VIM value is the percentage of voids contained in the total mixture. The VIM value affects the durability of the pavement layer, the higher the VIM value indicates the greater the voids in the mixture so that the mixture is hollow.

VFB (Void Filler in Bitumen)

VFB (*Void Filled with Bitumen*) is the portion of the volume of voids in the aggregate (VMA) that is filled with effective asphalt, expressed as % VMA.

Table 3. VFB Value [6]

Test Piece	VFB	
	Asphalt PG 70	**Asphalt Pen 60/70**
After Soaking 1x30 minutes at 60ºC		
1	81,34	80,60
After Soaking 1x24 hours at 60ºC		
1	76,07	65,07

Based on Table 3, the above test results, the VFB value decreased in 1x24 hour soaking at 60oC. The VFB value is the percentage of pores between aggregate grains filled with asphalt, so VFB is part of the VMA filled with asphalt and includes asphalt absorbed by each aggregate grain. Based on the required 2018 bina marga specification standard of at least 60%, it can be concluded that the value in the VFB test on pen 60/70 asphalt and PG 70 asphalt meets the requirements.

Stability

Stability is the ability of an asphalt mixture to resist deformation due to vehicle loads on it without changing shape or flow. The stability value is influenced by the composition and gradation of the aggregate mixture, the asphalt content and the type of asphalt used in the mixture.

Table 4. Stability Value [6]

Test Piece	Stability	
	Asphalt PG 70	**Asphalt Pen 60/70**
After Soaking 1x30 minutes at 60ºC		
1	2033	1076
2	2230	1063
3	2016	1076
Avg	2093	1072

Test Piece	Stability	
	Asphalt PG 70	**Asphalt Pen 60/70**
After Soaking 1x24 hours at 60ºC		
1	1639	1076
2	1737	1020
3	1771	1033
Avg	1716	1043

Based on Table 1, it shows that the asphalt mixture using PG 70 polymer asphalt has a higher stability value than the asphalt mixture using pen 60/70 asphalt. This is because PG 70 polymer modified asphalt has a higher viscosity which results in a stronger bond between asphalt and aggregate.

Flow

Melt/flow is the amount of vertical deformation in the test specimen due to the loading received and stability decreases.

Tabel 5. Flow Value (*Flow*)

Test Piece	Flow	
	Asphalt PG 70	**Asphalt Pen 60/70**
After Soaking 1x30 minutes at 60ºC		
1	3,8	3,1
2	4,0	2,9
3	3,9	2,5
Avg	3,9	2,9
After Soaking 1x24 hours at 60ºC		
1	3,7	3,1
2	4,2	2,9
3	4,0	2,5
Avg	3,9	2,8

Based on Table 1, it shows that the asphalt mixture using PG 70 polymer asphalt has a higher melt/flow value compared to the asphalt mixture using pen 60/70 asphalt. This is because the stability of PG 70 polymer modified asphalt has a higher viscosity which results in a stronger bond between the asphalt and the aggregate.

Marshall Quotient

The Marshall Quotient is the result of dividing the melt (flow) by the stability value. This shows the result of the stiffness of the asphalt mixture in receiving loads. if the marshall quotient value is greater, the mixture is stiffer and vice versa. A very important factor in order to get a flexible mixture is stiffness. if the mixture is declared not stiff enough, the mixture will be very easy to deform and vice versa.

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Table 6. Marshall Quotient Value

Test objects	Marshall Quotient	
	Asphalt PG 70	Asphalt Pen 60/70
After Soaking 1x30 minutes at 60ºC		
1	535	347,09
2	557,5	366,55
3	516,92	430,4
Avg	536,47	381,35
After Soaking 1x24 hours at 60ºC		
1	442,97	347,09
2	413,57	351,73
3	442,75	413,2
Avg	433,10	370,67

The marshall quotient value in table 3 above shows that the marshall quotient value of asphalt mixtures using PG 70 polymer asphalt is greater than asphalt mixtures using pen 60/70 asphalt. These results indicate that the asphalt mixture using PG 70 asphalt has a greater stiffness value than the asphalt mixture using pen 60/70 asphalt.

Figure 2. Making Test Objects

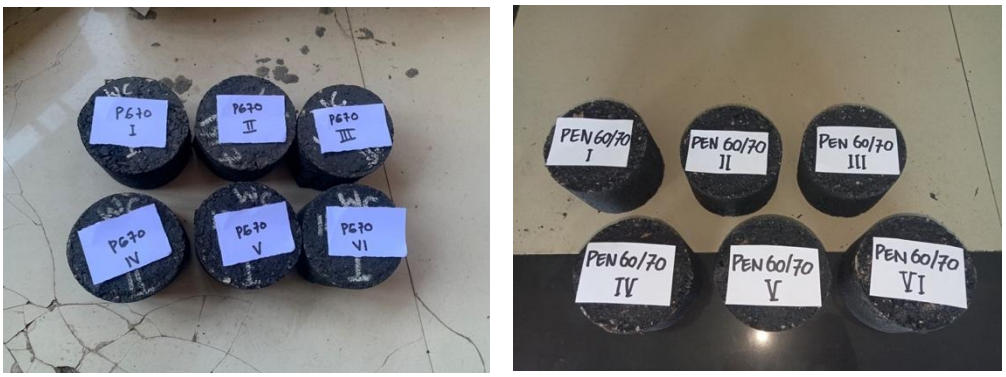

Figure 3. Test Objects (Briquettes) of Asphalt Pen 60/70 and Asoak PG 70 Mixtures

Figure 4. Marshall Ring Reading

Variasi	No. Sampel	Agregat	Kadar Aspal	Berat (Gram)			Volume	Berat Jenis		VMA	VIM	VFB	Bacaan Arloji Stability	*Stability*		*Flow* (Kelelehan)	Marshall Quotient
		(%)	(%)	Kering	Dalam Air	Jenuh		Aktual	GMM	(%)	(%)	(%)		Kali brasi	Cor relation	(mm)	kg/mm
		a	b	c	d	e	f = d – e	g = c / f	h	i	j	k	l	m	n	o	p = n / o
Aspal Pen 60/70	1	94,00	6,00	1192,8	684,8	1199,3	515	2,318					97	1076	1076	3.1	
	2			1195,9	689,8	1201,2	511	2,338					89	1063	1020	2.9	
	3			1194,1	688,8	1198,7	510	2,342					88	1076	1033	2.5	
Setelah direndam 1 x 30 menit pada suhu 60°C								**2,333**	**2,399**	**14,20**	**2,76**	**80,60**	**91**		**1340**	**2.9**	**462**
Aspal Pen 60/70	1	94,00	6,00	1176,4	680,7	1202,6	522	2,254					78	1076	1076	3.1	
	2			1185,3	685,5	1210,2	525	2,259					77	1063	1020	2.9	
	3			1181,8	676,5	1200,3	524	2,256					78	1076	1033	2.5	
Setelah Perendaman 1 x 24 jam pada 60°C								**2,294**	**2,399**	**17,01**	**5,94**	**65,07**	**77,7**		**1043**	**2,8**	**368**

Figure 5. Recap of Marshall Testing of Pen 60/70 Asphalt

Variasi	No. Sampel	Agregat	Kadar Aspal	Berat (Gram)			Volume	Berat Jenis		VMA	VIM	VFB	Bacaan Arloji Stability	*Stability*		*Flow* (Kelelehan)	Marshall Quotient
		(%)	(%)	Kering	Dalam Air	Jenuh		Aktual	GMM	(%)	(%)	(%)		Kali brasi	Cor relation	(mm)	kg/mm
		a	b	c	d	e	f = d – e	g = c / f	h	i	j	k	l	m	n	o	p = n / o
Aspal PG 70	1	94,00	6,00	1132,7	639,3	1134,0	495	2,290					130	1955	2033	3.8	
	2			1125,5	637,8	1127,9	490	2,296					136	2045	2230	4,0	
	3			1128,8	638,3	1129,9	492	2,296					123	1850	2016	3,9	
Setelah direndam 1 x 30 menit pada suhu 60°C								**2,294**	**2,363**	**15,63**	**2,92**	**81,34**	**130**		**2093**	**3,9**	**537**
Aspal PG 70	1	94,00	6,00	1156,6	651,1	1158,7	507,6	2,279					100	1504	1639	3.7	
	2			1157,6	659,8	1159,9	500,1	2,315					104	1581	1737	4,2	
	3			1159,9	654,7	1163,1	508,4	2,281					108	1624	1771	4,0	
Setelah Perendaman 1 x 24 jam pada 60°C								**2,298**	**2,40**	**16,83**	**4,05**	**76,07**	**104**		**1716**	**3,9**	**449,3**

Figure 6. Recap of Marshall Testing of PG 70 Asphalt

Both tables show that PG 70 asphalt performs better than Pen 60/70 asphalt, especially in terms of stability and Marshall Quotient. PG 70 asphalt is better able to maintain its strength after longer periods of immersion, making it a better choice for extreme environmental conditions or areas that are frequently exposed to standing water. In contrast, Pen 60/70 asphalt showed an increase in void space (VMA and VIM) and a more significant decrease in stability after immersion, indicating that

it may be more susceptible to degradation under moist or wet conditions. Thus, PG 70 asphalt is more recommended for use in areas with potential waterlogging or high traffic loads, while Pen 60/70 asphalt is more suitable for more conventional roads with lower environmental risks.

CONCLUSION

Based on the results of Marshall testing on PG 70 and Pen 60/70 asphalt mixtures conducted in accordance with the General Specifications of Bina Marga, it can be concluded that PG 70 asphalt shows better performance in all marshall parameters, such as stability and Marshall Quotient. The higher stability value of PG 70 asphalt indicates better resistance to traffic load and deformation. Thus, PG 70 asphalt is more recommended for use in more extreme environmental conditions or roads that have high traffic loads than Pen 60/70 asphalt. However, these two types of asphalt have different advantages and applications depending on the environmental conditions and roadwork needs, so the selection of asphalt type must be adjusted to the specific conditions of each road planning. From the results of this research, it is expected that the use of PG 70 polymer modified asphalt can be carried out in various projects according to the quality and quality required on existing roads in Indonesia in order to reduce the use of petroleum and improve the quality of roads in Indonesia.

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