

Glycerin Pitch as a partial replacement of pen 60/70 in AC-WC mixture

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Abstract. Glycerin pitch is a glycerol refining product from the oleochemical industry with a processing cost of US\$ 400/ton. In this research, GP is used as an alternative asphalt material to replace and reduce the use of imported asphalt. GP came from 13 Indonesian oleochemical companies and was categorized based on inorganic content with sample 1 being less than 10% with an optimum GP content of 27% and sample 2 being more than 10% with an optimum GP content of 14.2%. The primary objective of this study was to explore the potential of GP as a substitute for imported asphalt. The test results showed that the optimum asphalt content for GP in sample 1 was 6% which resulted in a density of 2.26 g/cm³, VIM 4.4%, VMA 18.77%, VFB 76.53%, stability 619 kg, flow 2.83 mm, MQ 211 kg/mm. In sample 2, optimum binder content was determined at 6.1%, resulting in density of 2.34 g/cm³, VIM 5%, VMA 15.68%, VFB 68.02%, stability 1092.3 kg, flow 3.45 mm, and MQ 316 mm. The optimized Gp content value of 27% and 14.2% Gp can reduce the amount of asphalt with Marshall test results with the best stability value in sample 2.

1 Introduction

Asphalt or bintumen is one of the materials for making flexible pavement where asphalt consists of hydrocarbons with thick characteristics [1]. Asphalt has a complex chemical composition with characteristics that depend on time and temperature [2], and Indonesian asphalt needs around 1.06 million tons a year with the Percentages is with 16.5% Pertamina production, 0.5% asbuton asphalt and 83% imported [3]. The unmet needs encourage alternatives to reduce imported asphalt levels, one of which is with Glycerin pitch as an asphalt mixture material which is one of the wastes produced from the oleochemical industry [4]. Glycerin pitch is alkaline gel that is brown to dark brown in colour [5], containing organic impact on the environment [6]. The cost that must be prepared for handling 1 ton of glycerin pitch costs around US\$ 400 [7]. Glycerin pitch as an additive has been glorified before such as Glycerin pitch in asphalt mixtures for stone matrix asphalt with a maximum addition of 22% at the binder asphalt pen 60/70 limit [8], and the effect of adding Glycerin pitch on asphalt properties with a maximum value for the addition of glycerint of 15% at the binder asphalt pen 60/70 [9]. In this research Glycerin pitch is used as a substitute for binder asphalt pen 60/70 for AC-WC asphalt mixture. A type of pavement that is widely used in Indonesia

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is AC-WC where this type of pavement is a type of sustainable pavement layer and is directly related to the tire of the vehicle [10]. This asphalt mixture will be added with 2 samples of glycerin pitch which has been grouped based on inorganic content from 13 different companies and is expected as a substitute for asphalt and can utilize oleochemical waste.

2 Material

2.1 Binder asphalt pen 60/70

The asphalt used in this research is asphalt with specifications binder asphalt pen 60/70 originating from PT Anten Perkasa. the asphalt obtained is tested for characteristics in the Bandung polytechnic material laboratory with the results presented in Table 1.

Table 1. Result characteristics of binder asphalt pen 60/70 asphalt.

No	Test Parameter	Unit	Type I: Asphalt Pen 60-70	
			Specs	Results
1	Penetration, 25°C, 100 gr, 5 sec (1 Divisi=0.1 mm)	0,1 mm	60-70	62,83
2	Softening Point	°C	≥ 48	49,50
3	Kinematic Viscosity 135 °C	cSt	> 300	551,24
4	Ductility, 25 °C, 5 cm/minute	Cm	> 100	≥ 100
5	Flash point with Cleavelen Open Cup	°C	> 232	340
6	Specific gravity	gram/cc	≥ 1,0	1,014

2.2 Glycerin pitch

Glycerin pitch is a material originated from glycerol which is a side product of biodiesel [11] Glycerin pitch is a residue or waste generated from the purification process of crude glycerol, which is a by-product of the oleochemical industry [12], with characteristics of sticky viscosity with high fatty acid content [13], Crude glycerol is a low purity product. The contents of crude glycerol are salts, fatty acids, soaps, methanol, water, and residual reactants. It contains 40-70% glycerin [14,15]. Glycerin pitch has the characteristics in Table 2. Glycerin pitch in this research comes from 13 Indonesian oleochemical companies as in Table 3 which are classified based on inorganic content. In this research, inorganic content less than 10% is called sample 1 and inorganic content more than 10% is called sample 2. As in Figure 1.



Fig. 1. Glycerin pitch sample 1 and 2.

Table 2. Characteristics of glycerin pitch.

Test Parameter	Unit	BS 2622:1979[8]	Results
PH	-	-	>10
Glycerol	%	>80	13.02
Moisture Content	%	No	2.56
Ash Content	%	<1.0	35
Saponification rate	-	-	-
Matter organic non glycerol (MONG)	%	<1.5	14.45
Appearance	-	-	Brownish solid

Glycerin pitch is one of the waste products [16] Oleochemical companies in Indonesia that participated in this study were 13 companies in Indonesia. Glycerin pitch is extracted to determine the inorganic content of each Glycerin pitch sample presented in table 3.

Table 3. Eleochemical company.

No.	Sample	Code	Inorganic Content
1	Musim Mas I	MM1	16,71%
2	Nubika	NBK	15,48%
3	Musim Mas II	MM2	7,98%
4	Eco 03	EGF	58,43%
5	Eco 01	EGH	52,17%
6	Energi sejahtera mas	ESM	8,40%
7	non salted	MMN	11,51%
8	salted	MMS	5,59%
9	apical	APL	0,40%
10	Soci I	SCH	10,09%
11	Soci II	SCF	10,09%
12	Domas	DMS	4,28%
13	Wilmar (hidrolisis)	WLH	3,09%
14	Wilmar (fame)	WLF	14,45%
15	Unilever	UNV	17,82%

3 Research and methods

In research before the levels of glycerin pitch for replacement materials on binder asphalt pen 60/70 were tested at 15%, 20%, and 25% with the optimum GP value at 15% GP content [9] and the addition of Glycerin pitch Stone Matrix Asphalt (SMA) for basphalt based on penetration and softening point on binder asphalt pen 60/70 with 0%, 15%, 20% and 25% GP content variation with the optimum GP content of 22% [8]. This research plan tests the characteristics of binder asphalt pen 60/70 with the addition of glycerine in sample 1 with additions starting from 0%, 20%, 25% and 30% and sample 2 0%, 13%, 15%, and 20% of the weight of the asphalt. After that proceed to make marshall test specimens with asphalt and maximum GP for sample 1 and sample 2. The marshall test is a testing method to determine the characteristics of the mixture of stability (Stability), Melting (Flow), Voids in the mixture (VIM), Voids in aggregates (VMA) and voids filled by asphalt (VFA) [17].

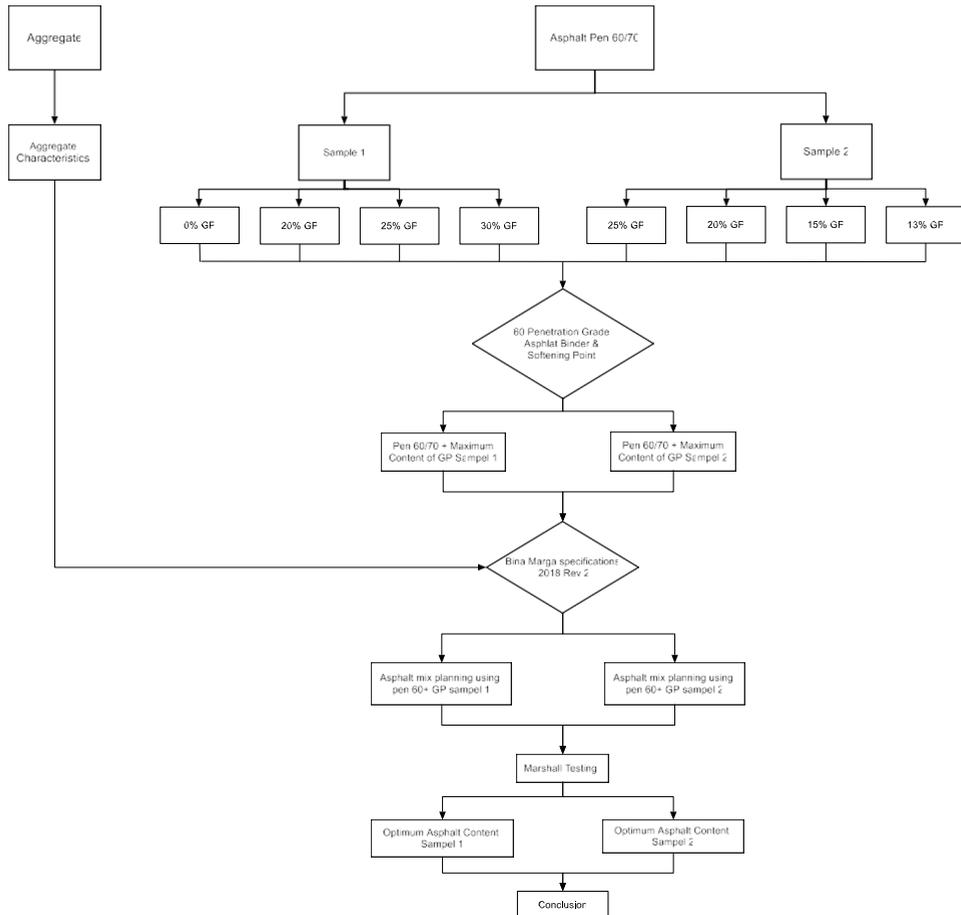


Fig. 2. Flowchart of the experimental procedure.

4 Result and discussion

4.1 Asphalt binder substitution penetration and rheology asphalt

The results of testing the characteristics of asphalt with the addition of glycerin pitch based on penetration testing with binder asphalt pen 60/70. For sample 1, the addition of GP increases the penetration value in contrast to sample 2, the addition of GP lowers the penetration value. The results of penetration testing with the addition of GP are still within the range of binder asphalt pen 60/70 specifications for sample 1 is 27% and the penetration value for sample 2 is 14.2% as shown in Figure 4.

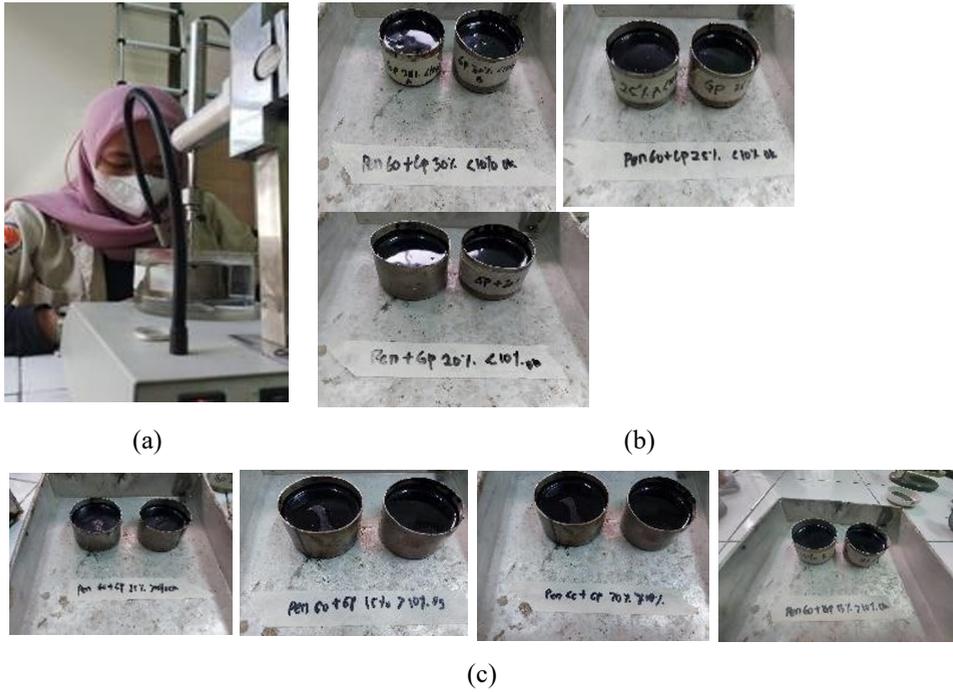


Fig. 3. (a) Penetration test, (b) Test specimens' sample 1 (c) Test specimens' sample 2.

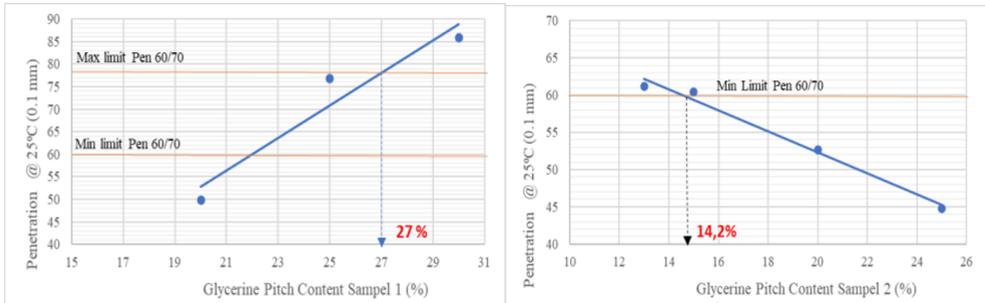


Fig. 4. Effect of adding Glycerin pitch on asphalt penetration binder asphalt pen 60/70 sample 1 and sample 2.

The results of the Binder asphalt pen 60/70+ Glycerin pitch asphalt characteristics test are presented in Table 4.

Table 4. Characteristics test results of Pen60/70+ Glycerin pitch asphalt.

No	Test Parameter	Unit	Type I Asphalt Pen 60-70	Results	
			Specs	Sample 1	Sample 2
1	Penetration, 25°C, 100 gr, 5 sec (1 Divisi=0.1 mm)	0,1 mm	60-70	76,58	61,23
2	Softening Point	oC	≥ 48	60,5	60
3	Kinematic Viscosity 135 °C	cSt	> 300	365,759	1092,25
4	Ductility, 25 °C, 5 cm/minute	Cm	> 100	≥ 100	≥ 100
5	Specific gravity	gram/cc	≥ 1,0	1.07	1.074

4.2 Asphalt concrete wearing coarse (AC-WC)

Results from penetration testing with 2 different GP samples. Therefore, 2 variations were made for the asphalt mixture as follows:

1. AC-WC with Binder asphalt pen 60/70 + 27% GP
2. AC-WC with Binder asphalt pen 60/70 + 14.2% GP

The results of the sieve test for AC-WC gradation Figure 5

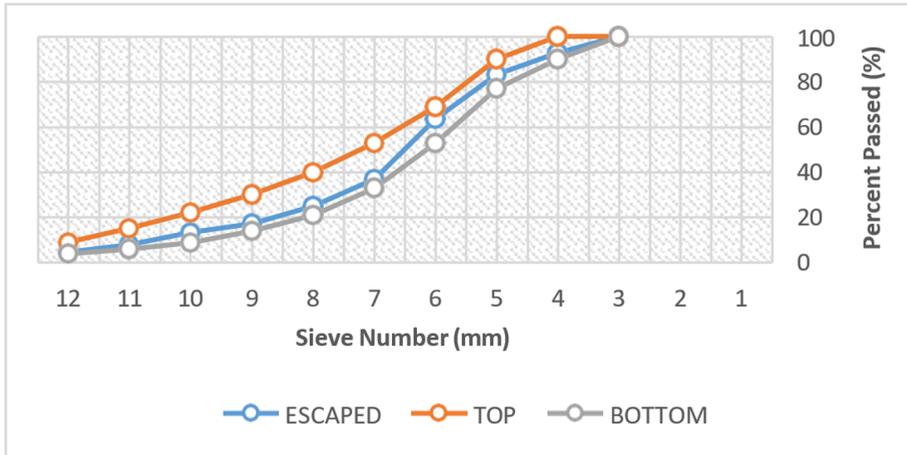


Fig. 5. AC-WC aggregate gradation.

The asphalt mixture is calculated based on the planned Optimum binder content (Pb) with AC-WC gradation based on equation 1 as follows.

$$Pb = 0,035 (\%CA) + 0,045 (\%FA) + 0,18 (\%Filler) + K \quad (1)$$

where:

- Pb (%) = Reference asphalt content, percent by weight of the mix,
 - CA (%) = Percent coarse aggregate (percentage of retained aggregate No. 4 (4.75 mm)),
 - FA (%) = Percent of fine aggregate (percentage of aggregate passing No. 4 (4.75 mm) and retained on sieve No. 200 (0.075 mm)),
 - Filler (%) = Percent filler (percentage of aggregate passing No. 200 (0.075 mm)),
 - K = Constant (0.5–1.0).
- $$= 0,035 (\% 80) + 0,045 (\% 10,5) + 0,18 (\% 9,5) + 2,0175 \%$$
- $$= 6 \%$$

4.3 Marshall methods

In this test specimen making for marshall testing, 3 test specimens were made at each asphalt content. asphalt content based on Pb values starting from 4%, 4.5%, 5%, 6% and 6.5% asphalt content. The results of marshall testing on 2 samples that have been tested based on the characteristics of the asphalt mixture for the AC-WC mixture are shown in Table 5. Testing on sample 1 with asphalt mixture obtained Sample 1 optimum binder content (OBC) value for Densiti 2.26 g/cm³, VIM 4.4%, VMA 18.77%, VFA 76.53%, Stability 619 kg, Flow 2.83 mm, MQ 211 kg/mm. as in Figure 6.

Table 5. Marshall and OBC test results with Glycerin pitch n.

Mixture Characteristics	Unit	Specification	Test Results	
			Sample 1	Sample 2
Asphalt content	%	-	6	6,1
Density	g/cc	-	2,26	2.34
Void in Mineral Aggregate, VMA	%	Min 17	18,77	15,68
Void in Mixture, VIM	%	3,0 - 5,0	4,4	5
Void Filled with Bintumen, VFB	%	-	76,53	68,02
Stability	kg	> 600	619	1092,3
Flow	mm	2,0 - 4,5	2,83	3,45
Marshall Quotient	kg/mm	> 250	211	316

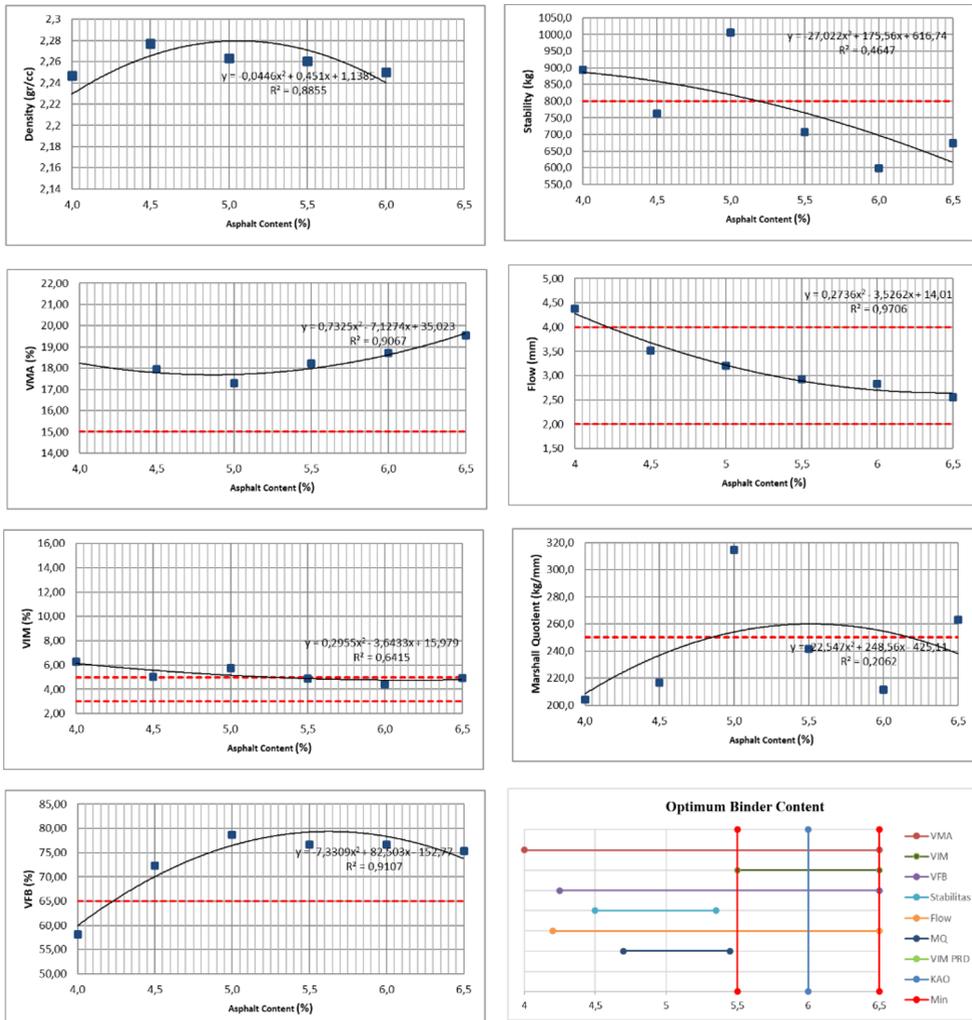


Fig. 6. Marshall and OBC graphs of AC-WC Mix + Sample 1.

Sample 2 was obtained an optimum binder content (OBC) value of 6.1% with a density value of 2.34 g/cm³, VIM 5%, VMA 15.68%, VFA 68.02%, Stability 1092.3 kg with Flow 3.45 mm and MQ 316 mm. as in Figure 7.

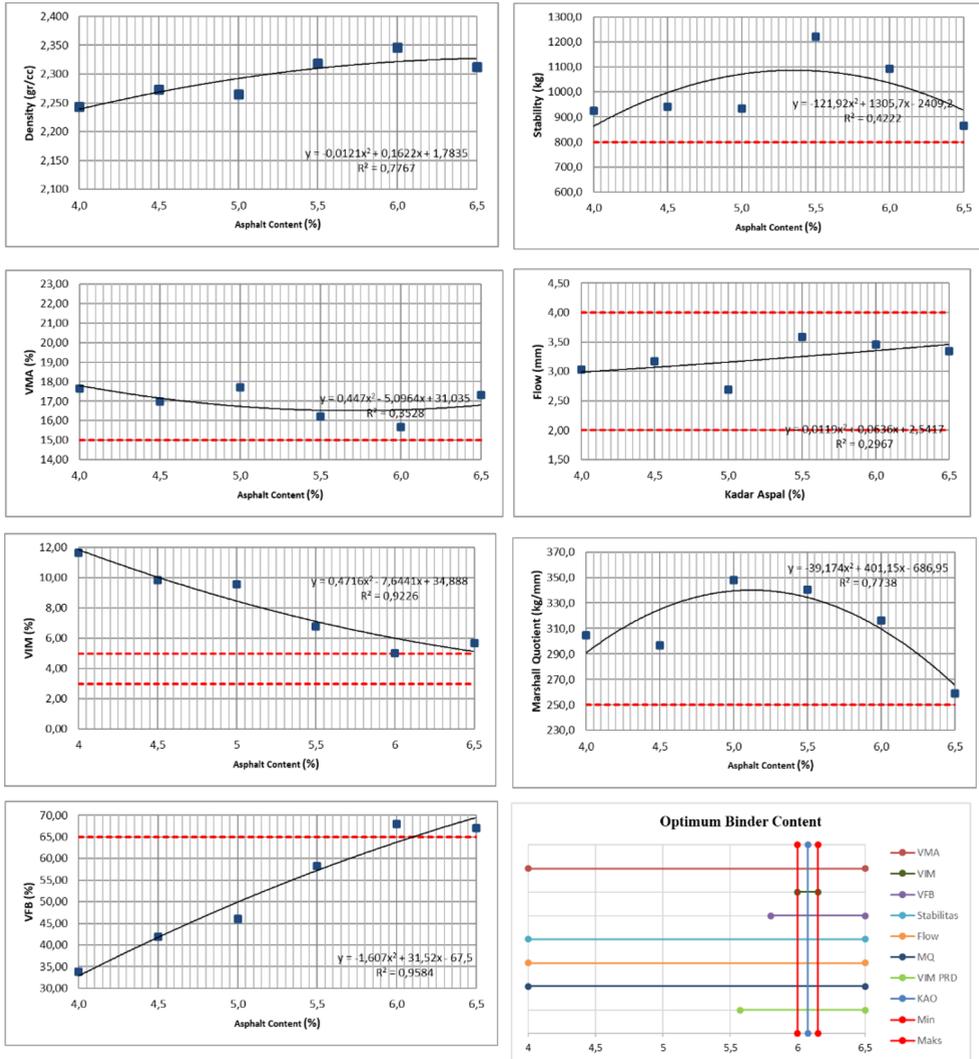


Fig. 7. Marshall and OBC graphs of AC-WC Mix + Sample 2.

The results of marshall testing on 2 samples have characteristics that do not meet the requirements of the 2018 rev 2 Bina Marga specifications. these characteristics are Marshall quotient in sample 1 and VMA in sample 2. In addition to these two characteristics in the marshall test sample 1 and sample 2 meet the required characteristics. In sample 1 based on the test results in table 6, the Marshall quotient value is 211 with an allowable specification value of more than 250. The low Marshall quotient value indicates that the asphalt mixture will tend to have greater plastic and flexible properties, which makes it easier to change shape or deform when enduring heavy traffic loads [18]. Sample 2 VMA does not meet the requirements with a value of 15.68 with a minimum value of 17. VMA is the air voids between aggregates in a paved mixture where asphalt fills the spaces or voids between the aggregates. The addition of asphalt content can cause the voids in the aggregate to become larger [19]. In marshall testing the featured value is the stability value which affects the durability and strength of the mixture which is an indication of the planned age [20]. Based on the stability value all samples meet the specifications with the highest value being in sample 2.

5 Conclusion

The conclusion of this research is the result of testing the characteristics of asphalt with Glycerin pitch for sample 1 maximum 27% and for sample 2 14.2%, Marshall testing obtained the optimum binder content (OBC) value for sample 1 of 6% and sample 2 of 6.1%, Testing the asphalt mixture in sample 1 with a GP content value of 27% obtained the following results Density 2.26 g/cm³, VIM 4.4%, VMA 18.77%, VFA 76.53%, Stability 619 kg, Flow 2.83 mm, MQ 211 kg/mm, Testing the asphalt mixture in sample 2 with a GP content value of 14% obtained the following results Density 2.34 g/cm³, VIM 5%, VMA 15.68%, VFA 68.02%, Stability 1092.3 kg with Flow 3.45 mm and MQ 316 mm. In this research, the use of glycerin pitch as an asphalt replacement resulted in differences in characteristics and performance. According to Marshall testing, the characteristics of sample 1 did not meet the requirements as per Bina Marga 2018 Rev 2, with Marshall Quotient indicating the ability of the asphalt mixture to resist deformation. While sample 2 did not meet the VMA requirement, which affects the durability and performance of asphalt. On the stability value all samples meet the specifications with the highest value being in sample 2. For future research, it is recommended to continue mechanistic testing to understand the properties of asphalt in conditions that simulate the temperature and environment in the field. Mechanistic tests for future research are suggested to be resilient modulus testing, rutting testing, and fatigue testing.

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