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Characteristics of AC-WC asphalt mixtures with volcanic ash deposits as cement substitutes in filler

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Abstract. filler is one of the ingredients functioning as a filler of ribs from a paved mixture. In a flexible pavement structure, the surface layer is the most upper part of the pavement which acts to hold the wheel load and also as a dense layer of water to protect the required road body, with a minimum thickness of 4 cm. This research was conducted by experimental method aiming to know the highest stability value using volcanic ash deposits as a substitute for cement in the filler. The deposits of volcanic ash used are 0%, 25%, 50%, 75% and 100% of the filler weight. The specimen material consists of several types, namely *Marshall*, PRD, IP, and GMM specimens. Concrete asphalt mixture is designed on the basis of the *Marshall* method. The results show that the volcanic deposit content is 0% with a stability value of 1133 kg, 15% with 1151 kg stability value, 30% with 1076 kg stability value, 50% with 1056 kg stability value, 70% with 1048 kg stability value, 85% with 1047 kg stability value and 100% with 1121 kg stability value. From these variations, the highest stability value is found in 15% volcanic ash deposition with 1151kg.

1. Introduction

Concrete asphalt is a mixture of continuous gradation aggregate with bitumen material. The primary power of asphalt concrete is situated in aggregate granules which locked into each other with filler in AC-WC mixture. Generally, filler that often used in concrete asphalt is cement, due to several chemical substances contained therein such as CaO, SiO2, Al2O3 and Fe2O3. If these chemicals mixed with liquid, it will transform into a solid substance and becomes aggregate binder [1].

However, this study exerts volcanic ashes deposit as filler to substitute cement [2]. In due to chemical characteristics inside the volcanic ash has similar content like cement. Among them are Si02, Me and Mg. Volcanic ashes deposit utilized in this study was taken from Burni Telong, the highlands in Gayo, Central Aceh and Benar Meriah. The present study aims to investigate stability and flow values of volcanic ash deposit as the substitution of cement in filler material.

2. Theoretical framework

2.1. Library review

Ali, conducted a study of the characteristics of a mixture of AC-WC with the use of volcanic ash and stone ash as fillers [3]. The plan asphalt content used in the mixture with volcanic ash as well as rock ash is Pb = 5.5% with a range of 4.5% asphalt plan; 5%; 5.5%; 6% and 6.5%, the research shows that:

- Marshall density and stability values with volcanic ash have higher values than mixture with rock as.

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- At all levels of asphalt, the value of flow mixture with rock ash is higher than in mixture with volcanic ash.

2.2. Mixture of concrete asphalt

2.2.1. Coarse aggregate. Coarse aggregate is constrained in sieve No.4 (4,75 mm), performed in wet and clean condition, well-preserved and free from clay and any other unwanted particles. Coarse aggregate serves as a mixture volume generator, which created from split and screen materials.

2.2.2. Fine aggregate. Fine aggregate consists of sands and stone ashes from passed sieving materials No.4 (4,75 mm) and constrained materials in sieve No. 200 (0,075 mm).

2.2.3. Filler. Filler is material with fine granules that serves as filler in asphalt mixture. Filler has a function as filling of air cavity on the material that hardening the asphalt lining.

2.2.4. Asphalt. Asphalt or bitumen is defined as brownish black material with viscoelasticity nature so that it will be soften and melted once it exposed to sufficient heating or vice versa [4].

2.3. Measurement of planned asphalt content

Measurement of planned asphalt content is executed to plan the mixture composition of test object. Early estimation of asphalt optimum level can be made once it passed through selection and combination of three aggregate fractions: coarse aggregate, fine aggregate and filler with the following calculation:

$$Pb = 0{,}035(\%CA) + 0{,}045(\%FA) + 0{,}18(\%FF) + K \quad (2.1)$$

Description:

Pb = planned asphalt content %
CA = Percent of constrained coarse aggregate in sieve 2,36 mm
FA = Percent of fine aggregate passed sieving 2,36 mm and constrained in no. 200
FF = Percent of filler
K = Constant of 0,5-1 for laston

2.4. Test object creation

Based on rule of RSNI M-01-2003, each of test objects require about ± 1200 gram aggregates to form a height of object test by approximately 63,5 mm. In the plan of weight traffic condition, requires compaction by 75 collisions for one test object. As for the amount of each test object can be seen in the table 1, 2 and 3.

Table 1. Marshall test object total amount.

ASPHALT	Level of Volcanic Ash Deposits Substitution on Filler						
LEVEL	15%+85%	30%+70%	50%+50%	70%+30%	85%+15%	100%	0%
Pb-1	3	3	3	3	3	3	3
Pb-0,5	3	3	3	3	3	3	3
pb	3	3	3	3	3	3	3
Pb+0,5	3	3	3	3	3	3	3
Pb+1	3	3	3	3	3	3	3

TOTAL: 105 objects

Table 2. Total amount of IP object test.

ASPHALT LEVEL	Level of Volcanic Ash Deposits Substitution on Filler						
	15%+85%	30%+70%	50%+50%	70%+30%	85%+15%	100%	0%
KAO(30 minutes of immersion)	3	3	3	3	3	3	3
KAO (24 hour immersion)	3	3	3	3	3	3	3

TOTAL: 42 objects

Table 3. Total amount of PRD test object.

ASPHALT LEVEL	Level of Volcanic Ash Deposits Substitution on Filler						
	15%+85%	30%+70%	50%+50%	70%+30%	85%+15%	100% volcanic	100% pc
Pb-0,5	1	1	1	1	1	1	1
Pb	1	1	1	1	1	1	1
Pb+0,5	1	1	1	1	1	1	1

TOTAL: 12 objects

3. Research methodology

Materials exerted in this study are coarse aggregate (split and screen) and fine aggregate (stone ashes) from around Bandung area. While, the filler applied is cement and volcanic ash deposit (from District of Central Aceh, Aceh Province) as the substitution. Equipment applied in this study is the equipment facilities at Materials and Transportation Laboratory of Civil.Engineering Department of Politeknik Negeri Bandung (State Polytechnic of Bandung) and Pusjatan.

4. Material test result

4.1. Coarse aggregate

Table 4. Coarse aggregate characteristics test result.

Testing	Method	Specification	Result
Coarse aggregate			
Specific Saturated Dry Gravity of Surface (SSD)	SNI 1969:2008	-	2,65
Bulk weight	SNI 1969:2008	Min. 2,5	2,58
Quasi Weight	SNI 1969:2008	-	2,78
Absorption	SNI 1969:2008	Max. 3%	2,77
Abrasion (500 rounds)	SNI 2417:2008	Max. 40%	14,19%
Sieving Pass No. 200	SNI 03-4142-1996	Max. 2%	0,46%
Index Oval-Flatten	ASTM D4791 comparison 1 : 5	Max. 10%	3,9%
Asphalt Viscosity	SNI 2439:2011	Min. 95%	100%

4.2. Fine aggregate

Table 5. Fine aggregate characteristics test result.

B	***Fine aggregate***			
1	Specific Saturated Dry Gravity of Surface (SSD)	SNI 1969:2008	-	2,64
2	*Bulk* weight	SNI 1969:2008	Min. 2,5	2,55
3	Quasi Weight	SNI 1969:2008	-	2,79
4	Absorption	SNI 1969:2008	Max. 3%	3,32
5	Sieving Pass No. 200	SNI ASTM C117:2012	Max. 10%	10,95%
6	Sand equivalent	SNI 03-4428-1997	Min. 60%	79,10%

Table 5 shows the fine aggregate characteristics test result. It shows that fine aggregate contains a huge amount of mud as it is revealed in the sieving pass test of No. 200 that exceeds 10% and its absorption value exceeds more than 3%.

4.3. Asphalt

Table 4.3 reveals asphalt characteristic test result. It shows that the asphalt has fulfilled the required specifications.

Table 6. Asphalt characteristic test result.

Testing	Method	Specification	Result
Penetration	SNI 2456:2011	60-70	63
Kinetic viscosity 135'C (cst)	SNI 7729:2011	≥ 300 cst	852,5 Cst
Softening point	SNI 2434:2011	≥ 48 ˚C	52,1˚C
Ductility	SNI 2432:2011	≥ 100 cm	140 cm
Specific gravity	SNI 2441:2011	≥ 1	1,04

4.4. Marshall test object creation

4.4.1. Aggregate mixture proportion

Table 7. Proportion of mixture 1 test object.

ASTM	**Sieve size (mm)**	**Heavy restrained**		**Cumulative (%)**		**Specification BINAMARGA 2010 [5]**	
		gr	**%**	**restrained**	**Pass the filter**	**Min**	**Max**
3/4"	19	0	**0**	0	100	100	100
1/2"	12,5	57,5	**5**	5	95	90	100
3/8"	9,5	132,25	**11,5**	16,5	83,5	77	90
No.4	4,75	258,75	**22,5**	39	61	53	69
No.8	2,36	207	**18**	57	43	33	53
No.16	1,18	143,75	**12,5**	69,5	30,5	21	40
No.30	0,6	97,75	**8,5**	78	22	14	30
No.50	0,3	74,75	**6,5**	84,5	15,5	9	22
No.100	0,15	57,5	**5**	89,5	10,5	6	15
No.200	0,075	46	**4**	93,5	6,5	4	9
Pan	<0.075	74,75	**6,5**	100			
TOTAL WEIGHT		**1150**	100	632,5			

Table 7 shows the aggregate requirements for one Marshall test item for each filter size from filters 19 mm to filters size <0.075 mm.

4.4.2. Asphalt content plan measurement. Planned asphalt level (Pb) is measured by using the following formula:

Pb = 0.035 (%CA) + 0.045 (%FA) + 0.18(%FF) + K
Description:

CA = Percentage amount of constrained aggregate from ¾" until No. 8
= 0% + 5% + 11,5% + 22,5% + 18%
= 57%

FF = Percentage amount of constrained aggregate from No.16 until No. 200
= 12,5% + 8,5% + 6,5% + 5% + 4%
= 36,5%

FA = Percentage amount of constrained aggregate
= 6,5

K = 0.5

Pb = 0.035 (57%) + 0.045 (36,5%) + 0.18(6,5%) + 0.5
= 5.31 % rounded into 5,5 %.

4.5. Marshall test result

4.5.1. Stability value

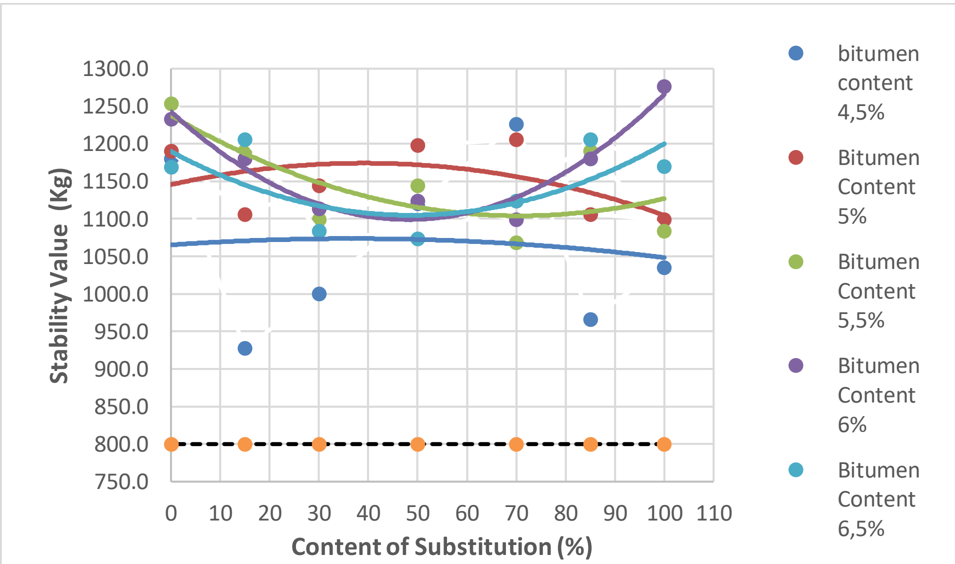

Figure 1. Curve of stability value.

Figure 1 shows the stability value on AC-WC mixture with various filler substitution level and asphalt level. The test result reveals that all the stability values fulfilled the requirement > 800 kg. However, the highest stability values lies in the substitution level of 100% and asphalt level 6% with value 1277 kg.

Figure 2 reveals flow value in the mixture of AC-WC with various filler substitution contents and asphalt level. The test result indicates that all these flow values did not meet the expectation and exceed the maximum limit (4mm). It is due to the high mud content in fine aggregate.

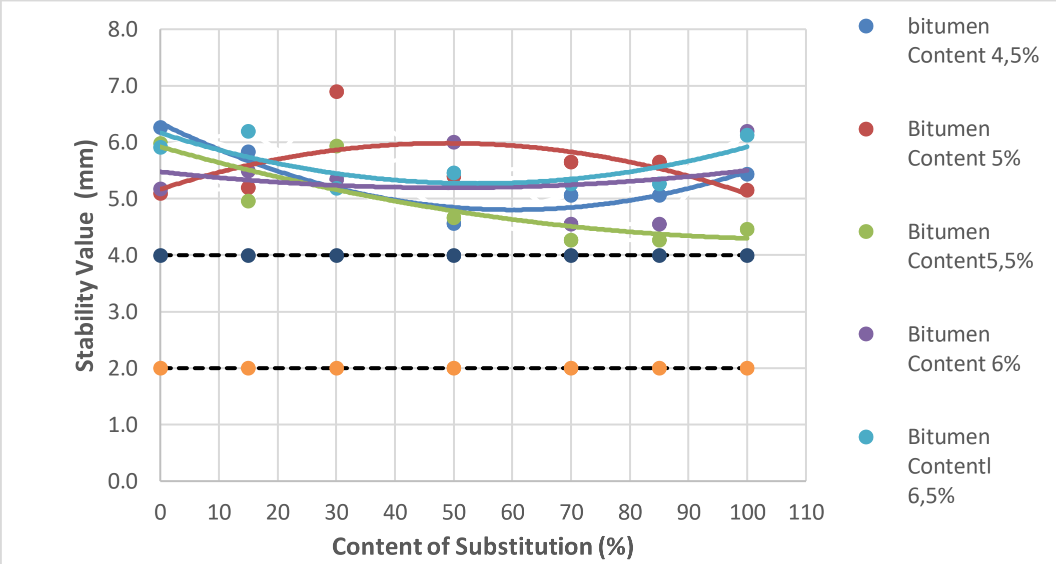

Figure 2. Curve of flow value.

5. Conclusion

Based on the result, several conclusions can be compiled as follows:

- All the characteristic of coarse aggregate fulfills the requirement specification.
- Fine aggregate contains a great amount of mud as being seen in the sieving pass test of No. 200 that exceeds 10% and its absorption value exceeds 3%.
- The highest stability value lies on 100% substitution level and Asphalt Level by 6% with value of 1277 kg.
- All of the flow values does not meet the requirement and exceeds the required maximum limit (4mm). It is due to the high mud content in fine aggregate.

6. Suggestion

Subsequent research changed the level of substitution of volcanic ash deposits in fillers.

References

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