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Durability Experiment Of Pg70 Modified Asphalt Using Portland Cement As Filler On Marshall Test

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ABSTRACT

Road pavement commonly undergoes damage due to factors such as heavy traffic loads, weather conditions, temperature variations, and inadequate construction practices. To enhance the strength of pavement structures, the utilization of asphalt mixtures with new specifications, particularly PG 70 modified asphalt, becomes essential. The main objective of this study is to assess the durability of the asphalt after 7, 14, 21, and 28 days in terms of Marshall parameters. This experimental research involves creating an initial sample consisting of 12 specimens with asphalt contents of 4.5%, 5%, 5.5%, and 6% to determine the Optimum Asphalt Content (KAO). The samples are subsequently immersed for 30 minutes at a temperature of 60°C. Next, three test specimens are prepared for each planned asphalt content to undergo immersion for 7, 14, 21, and 28 days. The study reveals that the planned KAO is obtained at 6%, and after immersion for 7, 14, 21, and 28 days, the average durability values are 100%, 126.9%, 115.4%, and 127.4%, respectively. Therefore, it can be concluded that the incorporation of Portland cement improves resistance against mixture damage caused by continuous water immersion and enhances the durability value as the immersion period increases.

1. Introduction

Road pavement is generally damaged due to the influence of excessive traffic loads, weather, temperature, and road pavement construction that does not meet other requirements [1], [2]. Therefore, these conditions must be supported by quality road construction to provide safety and comfort in driving [3], [4].

To increase the strength of the pavement structure, it is necessary to use asphalt mixtures with new specifications, one of which uses PG70-modified asphalt. PG 70 modified asphalt is a technology used to improve the performance of an asphalt mixture. PG 70 modified asphalt is made by mixing hard asphalt with an added material [5]. In addition to asphalt, coarse aggregate, and fine aggregate, filler is one component that has an important role. A small percentage of filler in a mixture does not mean that it does not have a big effect on Marshall

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properties, but how the performance of the mixture is affected by the traffic load received. The filler material used in this research is Portland cement [6][7].

Portland cement is one of the materials used for various building constructions, such as concrete, the reaction between Portland cement and water will form a binding mixture so that within a certain period of time it will harden [8]. So, in this case, the researcher tries to process Portland cement by mixing it with asphalt mixture, where cement functions as a filler.

By the description above, this research will discuss the "Durability of PG 70 Modified Asphalt Using Portland Cement as Filler Against Marshall Test" with the hope that the author can find out the effects that occur after the asphalt is 7, 14, 21, and 28 days old on the Marshall test. The level of each material to be used and the workmanship system using the Marshall method by the rules that already apply in the General Specifications of Bina Marga 2018 Revision 2 [9][10].

2. Research Method

The type of research to be conducted is experimental research, which involves conducting experiments and studies to determine a result. The objective of this experiment is to determine the effect of using a Portland Cement Filler on the stability of road pavement in Marshall testing [11]. This research will be carried out at the Laboratory of the Faculty of Engineering, Sang Bumi Ruwai Jurai University.

The materials used in this research are as follows:

a. Coarse and Fine Aggregates: The aggregates used in this research are obtained from PT. Sinar Batu Sakti Lestari - South Lampung.
b. Asphalt: The asphalt used in this research is modified PG 70 asphalt obtained from PT. Sarana Lampung Utama.
c. Filler: The filler used in this research is Type 1 Portland Cement obtained from PT. Tiga Roda.

Several equipment used for this research are as follows:

1. Set of Sieves: Sieves are used to separate aggregates based on their gradation.
2. Aggregate Testing Equipment: Aggregate testing is conducted using several equipment, including a drying oven, weighing scale, and specific gravity test equipment (pycnometer, weighing scale, heater).
3. Aggregate and Asphalt Mixture Characterization Test Equipment: The test equipment used is a set of equipment for the Marshall method, including:
   a. Marshall Compression Tool, consisting of a curved head with a testing ring capacity of 22.2 KN (2500 lbs), equipped with an algological flowmeter.
   b. Standard cylindrical specimen mold with a diameter of 10.16 cm (4 inches) and height of 7.5 cm (3 inches).
   c. Rammer with a flat tamping surface in the shape of a cylinder, weighing 4.536 kg (10 pounds) and a free fall height of 45.70 cm (18 inches).
   d. Ejector tool used to remove the compacted specimens from the mold.
   e. Immersion Tank.
   f. Supporting equipment such as mixing pans, heating stoves, thermometers, stirring spoons, gloves, wiping cloths, weighing scales, buckets, calipers, pans, and markers (Tipp-Ex) for marking the specimens.

The research involves several stages, including preparation, material testing, mix design, specimen preparation and testing using the Marshall apparatus, and data analysis and discussion. The materials used in the research include asphalt, coarse aggregate, fine aggregate, and filler (Portland Cement). Various equipment and tests are conducted to evaluate the properties of the materials. Mix design is performed to determine the composition of the asphalt mixture based on the specified gradation and optimum asphalt content [12]. Specimens are prepared and tested using the Marshall apparatus to determine stability and flow characteristics. The data obtained is analyzed and discussed, focusing on the relationship between the asphalt

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content and Marshall parameters. The research aims to provide insights into the performance of the asphalt mixture and contribute to pavement design and construction [13][14].

3. Results and Discussions

3.1 Results of aggregate gradation combination

Table 1. Combination results of aggregate gradation

Sieve Percentage	Description	% Combination	Filter Number										
			200	100	50	30	16	0,8	0,4	3/8	1/2	3/4	1
Material	Rock ash	39%	5.57	12.8	15.24	36.37	55.43	78.31	95.79	-	-	-	-
	Split 5-0 mm	26%	0.24	0.50	0.75	1.51	1.67	2.24	41.64	97.48	-	-	-
	Split 10-20 mm	22%	-	-	-	-	-	-	1.08	13.13	42.73	86.83	-
	Split 20-30 mm	10%	-	-	-	-	-	-	-	-	15.24	3.16	-
	Filler (%)	3.0%	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Combination	100%	5.23	8.14	17.58	17.58	25.05	34.12	51.42	70.42	78.93	92.42	100
Specification	Minimum		4.00	5.00	7.00	12.00	18.00	30.00	46.00	66.00	75.00	90.0	1.00
	Maksimum		8.00	13.0	20.00	28.00	38.00	49.00	64.00	82.00	90.0	100.00	100.00

Source: Laboratory Testing Results of Sang Bumi Ruwai Jurai University

Table 2 provides the combination results of aggregate gradation for the given materials. The table displays the percentage of each sieve size and its corresponding description. The combination consists of various materials, including rock ash, split sizes of 5-0 mm, 10-20 mm, and 20-30 mm, and a filler percentage of 3.0%. The table also presents the filter numbers for each combination. The percentages for each sieve size range from 0.4% to 95.79%, meeting the specified minimum and maximum requirements. These results indicate the distribution and proportion of different aggregate sizes used in the study [15].

3.2 Estimation of Optimum Asphalt Content (KAO)

To obtain the optimum asphalt content (KAO) of asphalt concrete pavement mixtures (Laston) in this study, the asphalt content of 4.5%, 5%, 5.5%, and 6% were used with each percentage of 3 test specimens [16].

Table 2. Marshall Test Result Data for KAO Determination

Asphalt Content (%)			4.5	5.0	5.5	6.0
Voids In The Aggregate (VMA)	***Marshall*** **Test**		**14.86**	**15.46**	**15.51**	**16.42**
	Specification	Min. Maks	14.00			
Cavity Filled With Asphalt (VFB)	***Marshall*** **Test**		80.61	84.71	86.73	93.22
	Specification	Min. Maks	65.00			
Cavity In The Mixture (VIM)	***Marshall*** **Test**		2.88	2.37	2.05	3.01
	Specification	Min. Maks	3.00 5.00			
Marshall Stability	***Marshall*** **Test**		1868.5	1558.2	1647.8	1558.2
	Specification	Min. Maks	1000			
Flow	***Marshall*** **Test**		5.1	5.1	5.4	3.8
	Specification	Min. Maks	2.00 4.00			
Marshall Quotient	***Marshall*** **Test**		372	288	314	414
	Specification	Min. Maks	250.00			

Source: Calculation Results

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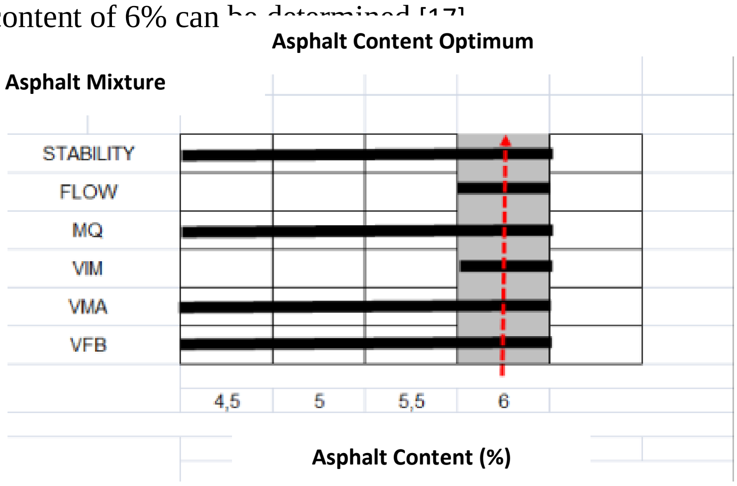
From the characteristic values of the mixture produced in the Marshall test above, the optimum asphalt content of 6% can be determined [17].



Source: Calculation Results

Figure 1. Graph of Optimum Asphalt Content Determination.

3.3 Marshall testing data at Optimum Asphalt Content

After obtaining the optimum asphalt content of 6%, 3 test objects were made at each age of 7, 14, 21, and 28 days by immersing the test objects according to the age of each sample. Then each test specimen is carried out the Marshall test to get the value of Stability, Melting (Flow), Marshall Quotient (MQ), asphalt-filled voids (VFB), voids in the mixture (VIM), and voids in the aggregate (VMA) [18]. The values of Marshall characteristics of the mixture at the optimum asphalt content of 6% are presented in Table 4 below:

Table 3. Immersion Marshall Test Result Data

Asphalt Age (Days)	Object Test (Fruit)	VMA (%)	VIM (%)	VFB (%)	Stability (kg)	*Flow* (mm)	MQ (kg/mm)
	1	17.46	2.34	86.57	1861.6	3.8	490
0	2	17.96	2.94	83.63	1613.4	3.7	436
	3	18.65	3.75	79.88	1199.7	3.8	316
Average		**18.02**	**3.01**	**83.36**	**1558.2**	**3.8**	**414**
	1	17.75	2.69	84.87	2109.8	2.6	811
7	2	17.49	2.39	86.36	1840.9	3.7	498
	3	17.31	2.17	87.44	1985.7	4.4	451
Average		**17.52**	**2.42**	**86.22**	**1978.8**	**3.6**	**587**
	1	16.92	1.71	89.92	1909.9	3.5	544
14	2	16.88	1.66	90.16	1716.8	4.2	409
	3	16.85	1.62	90.38	1799.5	3.7	486
Average		**16.88**	**1.66**	**90.15**	**1806.4**	**3.8**	**480**
	1	17.31	2.17	87.44	1696.1	3.5	485
21	2	16.63	1.36	91.80	1965.0	3.8	517
	3	17.42	2.30	86.79	1737.5	4.6	378
Average		**17.12**	**1.95**	**88.68**	**1799.5**	**4.0**	**460**
	1	18.14	3.15	82.62	2089.1	3.6	580
28	2	17.60	2.52	85.71	1985.7	3.8	523
	3	16.35	3.15	80.71	1882.2	4.2	448
Average		**17.36**	**2.94**	**83.01**	**1985.7**	**3.9**	**517**

Source: Calculation Results

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

This table presents the data from the Marshall test conducted on different asphalt ages (in days) and test objects. Several parameters were measured in this test, including VMA (%), VIM (%), VFB (%), Stability (kg), Flow (mm), and MQ (kg/mm).

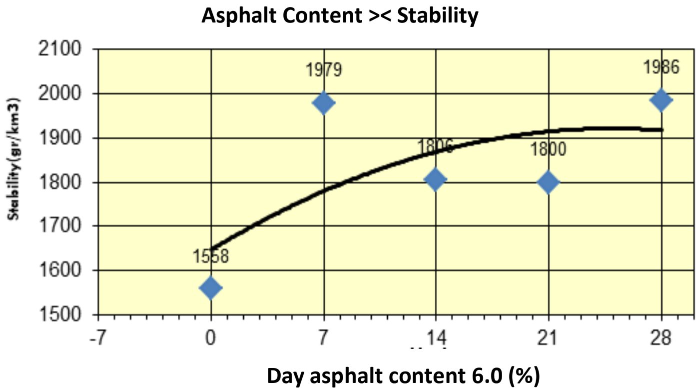
At 0 days asphalt age, test object 1 had a VMA of 17.46%, VIM of 2.34%, VFB of 86.57%, stability of 1861.6 kg, flow of 3.8 mm, and MQ of 490 kg/mm. At 7 days asphalt age, test object 1 had a VMA of 17.75%, VIM of 2.69%, VFB of 84.87%, stability of 2109.8 kg, flow of 2.6 mm, and MQ of 811 kg/mm.

The average results for each asphalt age were also calculated. At 0 days asphalt age, the average VMA was 18.02%, VIM was 3.01%, VFB was 83.36%, stability was 1558.2 kg, flow was 3.8 mm, and MQ was 414 kg/mm.

Similar data was presented for 14, 21, and 28 days asphalt ages. The average values for each parameter were also calculated for each asphalt age.

This table provides information about the changes in the characteristics of asphalt mixtures during the immersion process. The data can be used to evaluate the effect of asphalt age on Marshall parameters and provide insights into the durability of asphalt mixtures using Portland cement filler.

A. Stability

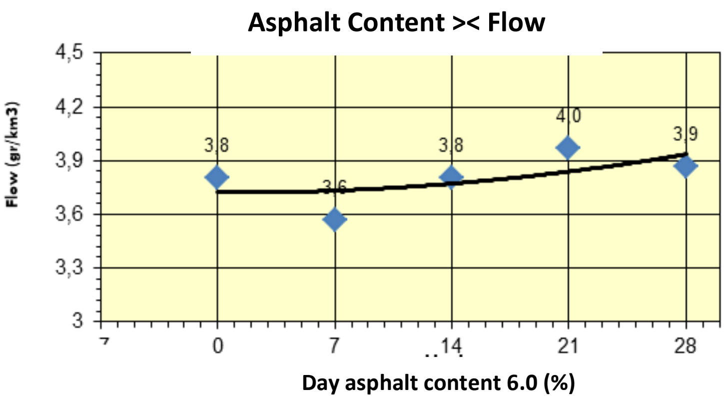


Source: Calculation Results

Figure 2. Stability Bath Graph.

Figure 2 shows that from day 0 to day 7, it increases. The increase in the stability value is also seen in the flow value where on day 0 to day 7 the flow decreases, then the mixture that has a low value of melt and high stability tends to be too stiff and brittle, then on day 14 to day 21 the stability value decreases and vice versa the flow value increases, this results in a mixture that tends to be plastic and easily deformed if it gets a traffic load.

B. Yield (Flow)



Source: Calculation Results

Figure 3. Flow bath graph

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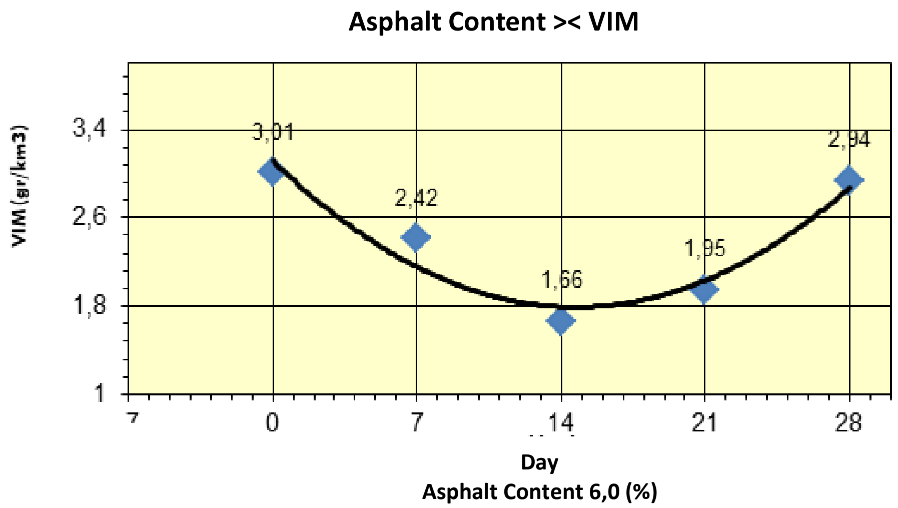
From the research results that can be seen in Figure 3 of the Flow value above, several factors affect the ups and downs of the Flow value including the compaction process, and the compaction temperature.

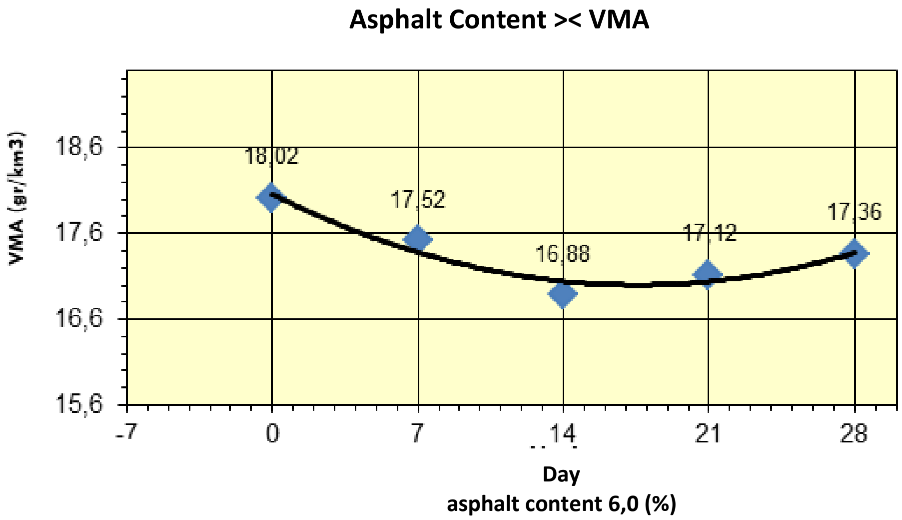
C. VIM (Void In The Compacted Mixture)



Source: Calculation Results
Figure 4. VIM bath graph.

The research results that can be seen in Figure 4 shows that with a soaking time of 0 days, 7 days, and 14 days, it decreases so that the waterproof layer and air do not enter the mixture which causes the asphalt to become brittle/brittle. Then on day 21 and day 28, the increase in the mixture using Portland cement filler increased [19][20].

D. VMA (Void In The Mineral Aggregate)



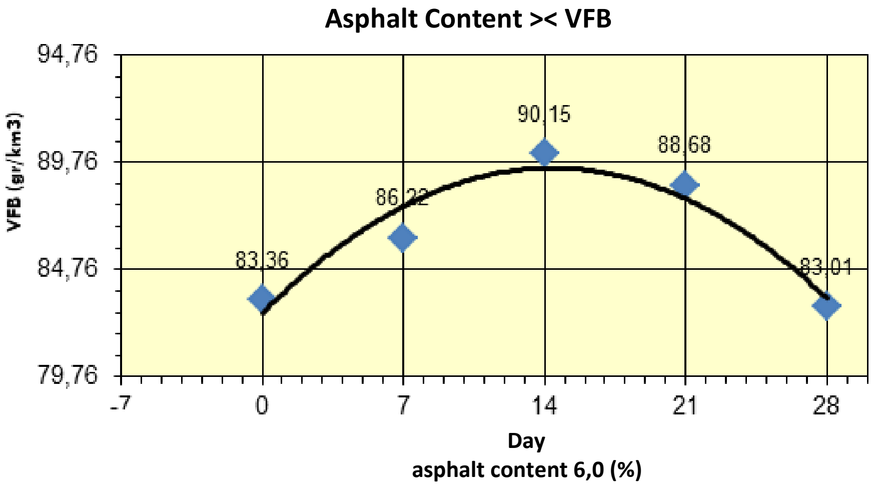
Source: Calculation Results
Figure 5. VMA bath graph.

From the test results for the VMA value on day 0 to day, 14 continues to decrease, this is due to the cavity between the aggregate particles can accommodate a large amount of asphalt

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

content, so the density between the aggregate grains is better or meets the standards set by the Bina Marga 2018 specification of at least 14%.

E. VFB (Void Filled By Bitumen)

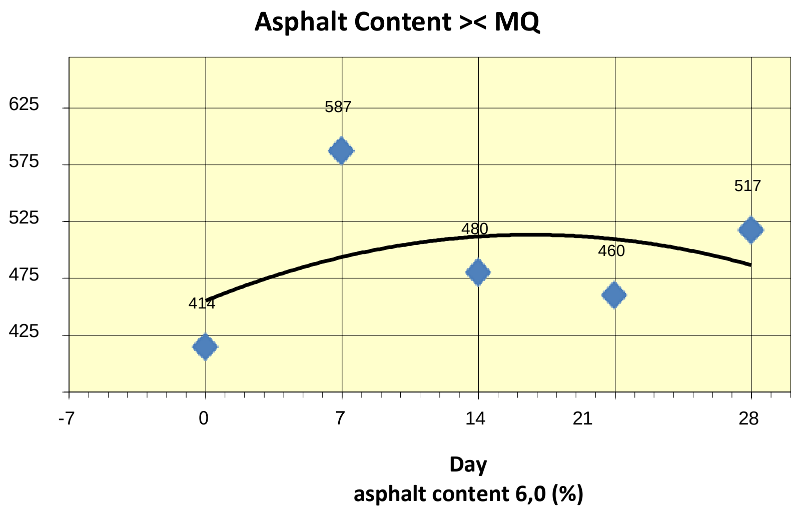


Source: Calculation Results

Figure 6. VFB soaking graph.

Figure 6 shows that the VFB value from day 0 to day 14 increased, this is because the voids between the aggregate grains are still large enough to hold the asphalt, the greater the asphalt content, the more the voids are filled by the asphalt. Then on days 21 and 28, it decreased, meaning that the voids between aggregate grains were not filled by asphalt.

F. MQ (Marshall Quotient)



Source: Calculation Results

Figure 7. MQ bath graph.

From Figure 4.7 the MQ (Marshall Quotient) relationship at 0 days to 7 days increased then on day 14 to day 21 decreased but not so significantly, as well as on day 28 increased. By looking at the data in general above the greater the Marshall Quantient value means the stiffer the mixture, otherwise if the smaller the value, the more flexible the mixture [21].

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G. Durability

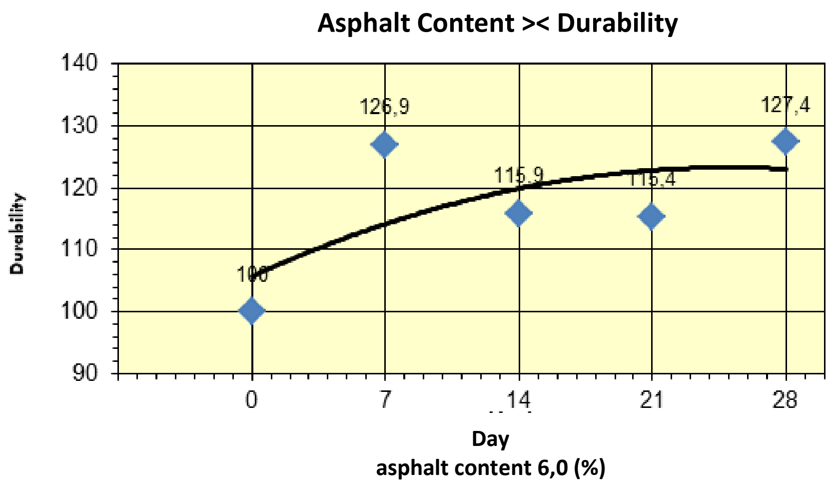
Durability test results of AC-BC mix with the addition of Portland Cement Filler where the specimens were immersed in water with immersion for 30 minutes, 7 days, 14 days, 21 days, and 28 days can be seen in the table below [22].

Table 5. Immersion Durability Results

30% Soaking Stability Minutes	*Marshall* Stability After Immersion		Mini mall requirements (%)	Durability Value IRS (%)
a	*b*	*c*	*d*	*e=(a/c) x100*
1558,2	0 Days	1558,2	90	100
	7 Days	1978,8		126,9
	14 Days	1806,4		115,9
	21 Days	1799,5		115,4
	28 Days	1985,7		127,4

Source: Calculation Results

Based on the Bina Marga 2018 Revision 2 specification, the requirement for the durability value or Residual Strength Index to see the durability of the asphalt mixture is at least 90% [23]. If these values are not met, the passage of water into the asphalt layer will be easier and this will cause the interlocking properties of the asphalt to decrease [24].



Source: Calculation Results

Figure 8. Graph of the relationship between asphalt content and durability

Based on the graph above, it can be seen that the longer the immersion of the test specimen in water, the greater the level of durability of the mixture. The durability value meets the specified requirement of 90%.

From the results of tests carried out on PG 70 modified asphalt using Portland cement as a Filler, the conclusion obtained from this study is that from all test objects based on the immersion durability graph on days 0, 7, 14, 21, and 28 tends to go up and down. But for all durability values meet the specified requirements of 90%.

The resulting durability value can be an illustration of the durability of modified asphalt with Portland cement filler in AC-BC mixtures. The use of Portland cement can increase the resistance to mixture damage due to continuous water immersion and increase the durability value with the length of immersion [25].

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H. Conclusion and Suggestion

After conducting the research, the following suggestions can be made:

1. There is still a need for further research on the effect of Portland cement utilization on other types of asphalt pavement such as AC-WC etc. especially to be able to serve heavy traffic conditions as an approach to field conditions.
2. Further research is needed on the planning process of AC-BC asphalt mixtures, with the utilization of Portland cement as a filler with a smaller percentage of use.
3. It is necessary to conduct research using different types of filler materials, such as the utilization of filler types from rice husk dust and processed wood husk dust which are very numerous and not utilized.
4. Further research is needed for a longer soaking period than 28 days.

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