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Analysis of the Addition of Binding Wire and Ethylene Vinyl Acetate on the Stability and Flow Performance of Asphalt Treated Permeable Superpave for Coastal Road Pavement

Ferdiano Yogi Pradana[1*] and Rachmat Mudiyono[1]

[1] *Civil Engineering Department, Universitas Islam Sultan Agung, Indonesia*
** Corresponding author: yogiferdiano@gmail.com*

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Abstract: The Pantura (Northern Coast) national road in Indonesia, frequently experiences problems with waterlogging, mostly caused by extreme weather conditions such as continuous rain, resulting in flooding and rising sea levels that inundate the road construction. To address these issues, an unconventional asphalt pavement design is needed. This study aims to create a Superpave (Superior Performing Asphalt Pavements) graded asphalt composition with EVA (Ethylene Vinyl Acetate) and Binding Wire additives that are expected to meet Marshall and Permeability criteria. The method used in this study is an experimental study. Test specimens were prepared and subjected to Marshall and Permeability tests. The specimens were prepared using EVA (Ethylene Vinyl Acetate) additives of 0%, 1%, 3%, and 5% and Binding Wire at 0%, 2%, 4%, 6%, and 8%. In the research results, along with the increasing percentage of EVA and Binding Wire, the highest stability value was obtained in the E0B8 Cement material variation of 2578.99 Kg. The highest Flow value was in E5B5 Cement of 3.90 mm. The highest Marshall Quotient value was in E0B8 Lime of 701.55%. The highest Void in Mineral Aggregate (VMA) and Void Filled with Asphalt (VFA) values were obtained in the E0B0 Lime material variation of 20.51% and 84.70%, respectively. The highest Void in The Mix (VIM) value was obtained in E5B8 Cement of 4.63%. While the highest Dry Density Permeability was in E5B8 of 0.92 gr/cm^2 Cement and the highest Permeability Coefficient was in E0B4 of 1.64528×10^{-5} gr/cm Limestone.

Keywords: Ethylene Vinyl Acetate; Binding Wire; Limestone; Marshall; Asphalt Superpave

1. Introduction

Several sections of road in Indonesia located in areas connected to the coast have problems with sea water inundation, which is mostly caused by extreme weather, resulting in tidal flooding or what is known as tidal flooding [1]. Rising sea levels inundate road construction, causing road performance to decline [2]. Therefore, there is a need for an extraordinary asphalt pavement (super asphalt pavement). In this study, researchers created an innovation called Superpave asphalt pavement (Superior Performing Asphalt Pavements). This asphalt is expected to be able to withstand all weather conditions (hot and rainy) and withstand excessive traffic loads. [3]. With the modification of the addition of Binding Wire (binding wire) to strengthen the ability of the pavement molecules because currently the coastal road area always experiences overload and over dimension which often causes damage to the road surface. Meanwhile, EVA (Ethylene Vinyl Acetate) has flexible properties, is easy to process, is resistant to low temperatures, is resistant to cracks due to pressure due to its properties that have good stiffness in withstanding loads.

In the following research to determine how much the performance of the road pavement increases due to the influence of the Superpave gradation type and the PG 70 asphalt binder is still very necessary to do, especially with the addition of Binding Wire ± 2 cm long, and EVA (Ethylene Vinyl Acetate) and limestone substitution as a substitute for filler. In this study, an exploration of the study of Marshall and Permeability characteristics testing will be carried out in the form of pavement resistance and water absorption.

2. Research Method

This study uses experimental research, namely research conducted with experiments in the laboratory. Furthermore, the data is processed by considering the requirements or specification standards to produce the desired comparison results. This research was conducted at the Pavement Laboratory of the Faculty of Engineering, Sultan Agung Islamic University Semarang based on the use of a hot mix asphalt system with Superpave grades. In this study, the intention is to research and test and provide treatment in the form of adding a percentage of Binding Wire 0%; 2%; 4%; 6%; 8% and EVA (Ethylene Vinyl Acetate) 0%; 1%; 3%; 5%, to the characteristics of Superpave asphalt.

2.1. Superpave Gradation

Superpave is a new specification for asphalt concrete mix gradation created by the Strategic Highway Research Program (SHRP) [4]. Superpave sets the target gradation specification requirements with the existence of a prohibition zone in the form of a maximum and minimum nominal size of Superpave gradation can be categorized as a gap graded type because the aggregate gradation conditions have a grain size in a fraction of a small amount or are limited for each hot asphalt mix design with the aim of reducing the effects of plastic deformation and initial cracking due to repeated vehicle or traffic loads. [5]. The Superpave mixture has a prohibited gradation zone in the Superpave mixture which will provide a role in the form of a larger cavity volume, with the hope that the asphalt used can fill the cavity to the maximum. [6].

2.2. Asphalt PG 70

Performance Grade (PG) is one of the methods used to classify asphalt based on its performance in road construction in Indonesia, namely Performance Grade PG-70 asphalt, a modified asphalt obtained from the process of combining conventional asphalt with DuPont™ Elvaloy® (elastomer) [6]. The PG-70 asphalt material was taken from the Asphalt Mixing Plant (AMP) of PT Mohandas Oelong Kendal, which will be used as material in the research. Asphalt testing is carried out to determine whether the asphalt material used is suitable for use as a mixture for flexible pavement and meets specifications. Test results can be seen in Table 1.

Table 1. Physical and Mechanical Properties of PG 70 Asphalt

	Test Property	**unit**	**Test Result**
Un-aged Asphalt	Penetration at 25°C, 100 gr, 5 s	0.1 mm	52.6
	Softening Point (Ring and Ball Test)	°C	62.65
	Flash Point (Cleveland Open Cup)	°C	314
	Ductility	cm	151
	Specific Gravity of Asphalt Binder	gr/ml	1.028
Rolling Thin-Film Oven Test (Short-Term Aged)	Mass Loss	%	0.0515
	Retained Penetration at 25 °C	%	54.3
	Ductility after RTFOT	cm	150

2.3. Aggregates

The aggregates used are coarse aggregate and fine aggregate. The coarse aggregate fraction retained by sieve No. 4 (4.75 mm) must be used in the mixture design. The coarse aggregate must meet the specified requirements and must be hard, durable, clean, and free from clay or other undesirable components. The material that passes through sieve No. 4 and is retained by sieve No. 200 is called fine aggregate, usually pure sand that has been screened by a stone crusher, or a mixture of both [7].

At the material supply stage, the materials were taken from the Asphalt Mixing Plant (AMP) of PT. Mohandas Oeloeng Kendal, see Fig. 1. All processes for making test specimens and subsequent material properties were carried out at the road transportation laboratory of Sultan Agung Islamic University, Semarang. The tools used to examine the aggregates include an abrasion tester, standard sieves, flake testers, and dryers.

(a)

(b)

Fig. 1. Aggregate material collection and source location: (a) raw aggregate materials, and (b) asphalt mixing plant (AMP) facility at PT Mohandas Oeloeng, Kendal.

2.4. Binding Wire

We take the binding wire from the remaining material of the PT. Griya Kontruksi Indonesia project, this binding wire will be used as an additional mixing material in the research asphalt job mix. It is used after cutting ± 2 cm, see Fig. 2, for the percentage of 0%, 2%, 4%, 6%, and 8%, of the Optimum asphalt content (KAO) in Superpave Asphalt. Binding wire acts as a mechanical reinforcing fiber. The use of metal fibers in the asphalt mixture can increase resistance to cracking and improve marshal stability if there is too much or it is not mixed evenly, potentially increasing initial porosity, but can reduce cracks that become water paths [8].

Fig. 2. Binding Wire Material

2.5. Ethylene Vinyl Acetate (EVA)

Waste from the use of PE - EVA plastic which will be processed into EVA (Ethylene Vinyl Acetate) or new plastic pellets, is carried out at CV Maju Plastik in the LIK Kaligawe Industrial Area, Semarang, which will later be used as an additional material in the asphalt job mix mixture with a percentage of 0%, 1%, 3% and 5% of the Optimum asphalt content (KAO) in Superpavent asphalt. acts as a modified asphalt that increases the stability and elasticity of the mixture. The collection of EVA plastic waste and processing into plastic pellets can be seen in Fig. 3. The optimum content increases resistance to permanent deformation (rutting) and EVA helps fill pores and increases the cohesion of the mixture, which generally reduces permeability (making the mixture more watertight) [9].

(a) (b)

Fig. 3. Collection of EVA plastic waste and processing into plastic pellets: (a) raw EVA plastic waste, and (b) processed EVA plastic pellets.

The flow diagram of the process of processing Ethylene Vinyl Acetate (EVA) plastic waste into pellets or plastic pellets can be seen in Fig. 4.

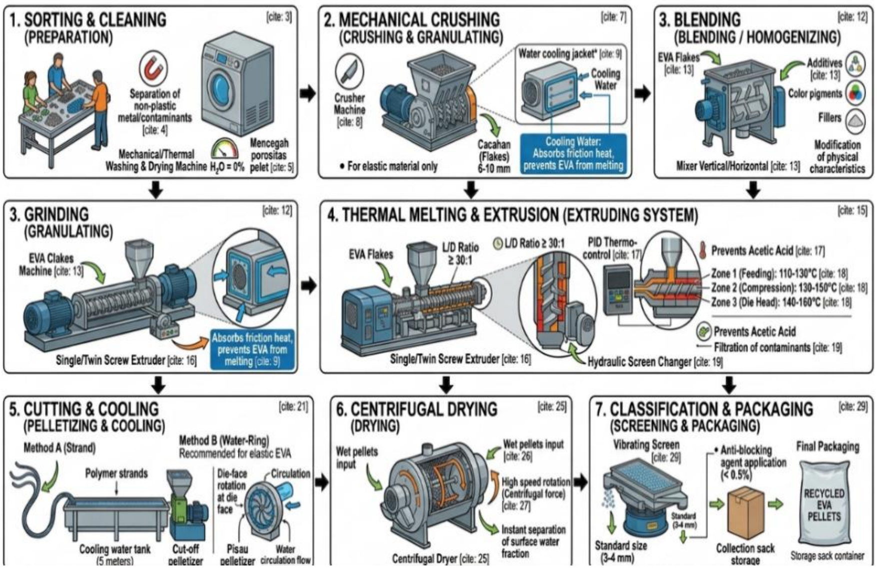

Fig. 4. Flowchart stages of processing EVA waste into pellets

2.6. Lime Stone

Limestone was taken from the Sukolilo Pati area, In this research, limestone functions as a partial substitute for Portland cement within a specific particle size distribution, precisely passing through the No. 100 sieve and retained on the No. 200 sieve, see Fig. 5. The addition of limestone to the asphalt mixture is a new innovation in optimizing natural resources and is also expected to function as asphalt stabilization to increase bearing capacity and reduce sensitivity to water [10].

Fig. 5. Lime Stone Material

2.7. Results of Concrete Aggregate Combination Calculations

The aggregate combination is a combination of each aggregate that passes the 2” sieve and is retained starting from the 1 ½ to # 100 sieve size, which consists of 2” aggregate up to sand [11]. For more details, see the table 2:

As illustrated in Table 2 regarding the aggregate combinations, the percentage of aggregates passing sieve no. 200 (0.075 mm) up to 1' is not allowed to exceed the lower and upper limits for each sieved aggregate. If there is an aggregate that exceeds the upper or lower limit, it is not permitted to be used as filler material in permeable asphalt Superpave.

Table 2. Sieve Analysis of Combine Aggregate

Sieve No.	Passing Percentage	Specification	
		Lower Limit	Upper Limit
1”	100.0	95	100
¾”	98.08	92.5	100
½”	85.19	79	89
3/8”	73.35	68	78
# 4	60.11	55.5	65.5
# 8	42.64	40.5	46.5
# 16	27.90	25.5	31.5
# 30	19.03	17	23
# 50	11.84	10	16
# 100	8.83	6	10
# 200	4.34	3	5

Table 3. Experimental composition and number of test specimens

No.	Mix Composition	Filler Material	
		Portland Cement	Limestone
1	EVA 0% & Binding Wire 0%	3 sample	3 sample
2	EVA 0% & Binding Wire 2%	3 sample	3 sample
3	EVA 0% & Binding Wire 4%	3 sample	3 sample
4	EVA 0% & Binding Wire 6%	3 sample	3 sample
5	EVA 0% & Binding Wire 8%	3 sample	3 sample
6	EVA 1% & Binding Wire 0%	3 sample	3 sample
7	EVA 1% & Binding Wire 2%	3 sample	3 sample
8	EVA 1% & Binding Wire 4%	3 sample	3 sample
9	EVA 1% & Binding Wire 6%	3 sample	3 sample
10	EVA 1% & Binding Wire 8%	3 sample	3 sample
11	EVA 3% & Binding Wire 0%	3 sample	3 sample
12	EVA 3% & Binding Wire 2%	3 sample	3 sample

No.	Mix Composition	Filler Material	
		Portland Cement	**Limestone**
13	EVA 3% & Binding Wire 4%	3 sample	3 sample
14	EVA 3% & Binding Wire 6%	3 sample	3 sample
15	EVA 3% & Binding Wire 8%	3 sample	3 sample
16	EVA 5% & Binding Wire 0%	3 sample	3 sample
17	EVA 5% & Binding Wire 2%	3 sample	3 sample
18	EVA 5% & Binding Wire 4%	3 sample	3 sample
19	EVA 5% & Binding Wire 6%	3 sample	3 sample
20	EVA 5% & Binding Wire 8%	3 sample	3 sample
	Normal Asphalt Content (4.5; 5.0; 5.5; 6.0; 6.5)	15 sample	15 sample
	Total of Test Specimen	75 sample	75 sample

2.8. Job Mix Design

The composition of modified asphalt with a planned asphalt content of 5.8% is ± 2 cm Binding Wire with a content of 0%, 2%, 4%, 6%, and 8% and EVA (Ethylene Vinyl Acetate) with a percentage of 0%, 1%, 3%, and 5%, for each Portland cement filler mixture of 75 test specimens, and a mixture with limestone filler of 75 test specimens. So, the total number of test specimens that need to be made is 150 test specimens for this study. All the specimen's variation can be seen in Tabel 3.

3. Result and Discussion

3.1 Marshall Test

If the job mix design and mix formula design have been determined, and 150 asphalt test specimens have been made, then all test specimens are weighed while still dry, then the test specimens are weighed after soaking and the test specimens are weighed again in the SSD state. After obtaining the weight of the test specimens, they are then immersed in a water bath (heating the liquid by soaking it in water that has been heated previously) at a temperature of 60ºC for 30 minutes. All test specimen samples in the water bath that have been soaked must immediately be tested on the Marshall tool to obtain stability readings and flow readings (melting) on the asphalt test specimen samples [12]. In order to obtain the KAO value (Optimum Asphalt Content), several parameters must first be obtained. The parameters obtained are VMA (Void in Mineral Aggregates), VIM (Void in Mix), VFB (Void Filled Bitumen), stability, flow (meltability), and MQ (Marshall Quotient).

The Marshall test results in this study are evaluated based on two distinct experimental groups. The first group comprises the modified asphalt mixture incorporating ± 2 cm binding wire and EVA combined with limestone, while the second group serves as the comparative mixture utilizing ± 2 cm binding wire and EVA combined with conventional Portland cement under Superpave specifications.

Void in Mix (VIM) Result of EVA (0%; 1%; 3%; 5%) + Binding Wire (0%; 2%; 4%; 6%; 8%) with Cement Filler compared to Limestone. VIM value is an indicator of durability or influences the durability of the asphalt concrete mixture. The results of the VIM examination of the asphalt concrete mixture are presented in Table 4 and Fig. 6., which shows the comparison of the Marshall VIM values using cement filler compared to limestone.

From the test results show that Portland Cement Filler provides a larger and more stable (dense) VIM value compared to Limestone Filler. It tends to produce a smaller and more porous VIM at the same percentage of EVA and Binding Wire. The addition of EVA + Binding Wire content with Portland Cement Filler and Limestone into the mixture causes the VIM value to increase as the EVA + Binding Wire content increases, but the value of Cement Filler with the most optimal value is in a mixture of 5% EVA and 8% BW with a value of 4.63%. greater than, Limestone with a value of 4.54%. The overall VIM value of each mixture has met the requirements of the 2025 Highway Engineering Specifications [7].

Table 4. VIM of Modified Permeable Superpave Mixtures with cement and limestone fillers

Composition	Void in Mix (%)	
	Cement	Limestone
E0B0	3.17	3.14
E0B2	3.31	3.28
E0B4	3.50	3.42
E0B6	3.93	3.58
E0B8	4.26	3.76
E1B0	3.41	3.27
E1B2	3.56	3.43
E1B4	3.77	3.62
E1B6	4.14	3.86
E1B8	4.26	4.06
E3B0	3.64	3.46
E3B2	3.84	3.62
E3B4	4.00	3.87
E3B6	4.15	3.99
E3B8	4.29	4.12
E5B0	3.92	3.77
E5B2	4.13	3.93
E5B4	4.30	4.19
E5B6	4.47	4.37
E5B8	4.63	4.54

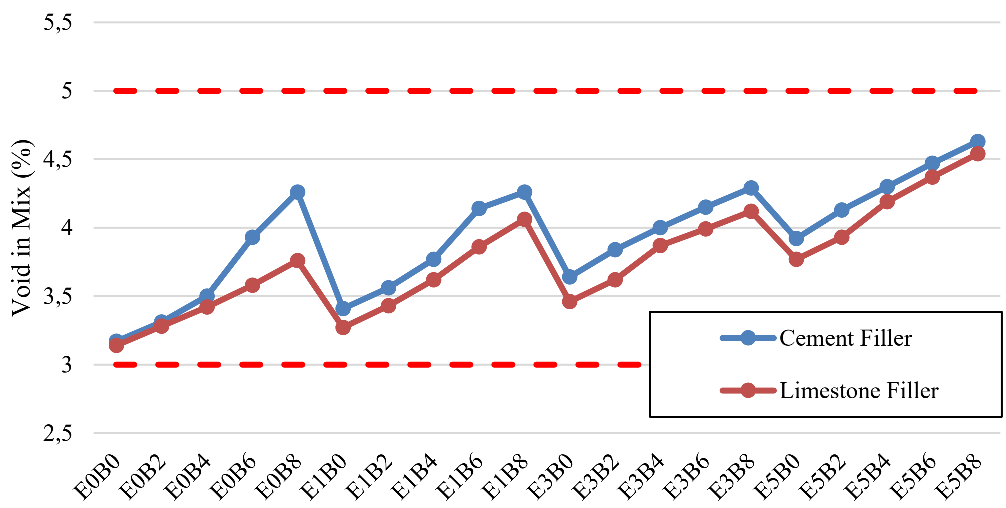

Fig. 6. VIM Comparison between cement and limestone filler mixtures

3.2. Marshall Stability of Modified Permeable Superpave Mixtures

The stability value is influenced by asphalt cohesion, asphalt content, friction (internal friction), interlocking properties of aggregate particles, shape and surface texture, and aggregate gradation. The stability value can be seen in Table 5 and Fig. 7. Marshall Filler Cement Results compared to Limestone

Table 5. Marshall stability of Modified Permeable Superpave Mixtures with cement and limestone fillers

Composition	Stability (kg)	
	Cement	Limestone
E0B0	1318.49	1148.20
E0B2	1910.85	1463.39
E0B4	2154.31	1536.56
E0B6	2511.78	2050.84
E0B8	2578.99	2350.19
E1B0	1197.22	1164.49
E1B2	1770.14	1730.74
E1B4	1956.72	1885.39
E1B6	2224.92	2167.92
E1B8	2347.90	2285.27
E3B0	1134.58	1085.50
E3B2	1575.96	1525.30
E3B4	1790.56	1690.81
E3B6	2044.49	1924.52
E3B8	2321.72	2214.78
E5B0	1027.71	954.34
E5B2	1246.69	1190.41
E5B4	1629.49	1422.61
E5B6	1893.90	1633.55
E5B8	2268.25	2065.63

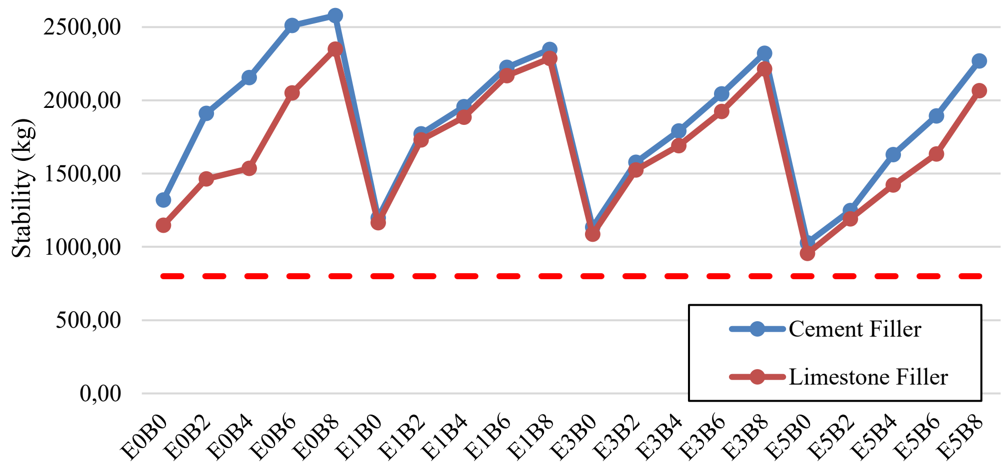

Fig. 7. Marshall Stability Comparison between cement and limestone filler mixtures

From the test results, it shows that Portland cement filler generally provides the optimum stability value for the EVA + Binding Wire mixture at 0% EVA + 8% BW Cement Filler content, which is 2578.99 Kg. While the optimum stability value for 0% EVA + 8% BW Limestone Filler content is 2350.19. The overall results of the stability value of each mixture have met the requirements of the 2025 Highway Engineering Specification [7].

3.3. Marshall Flow of Modified Permeable Superpave Mixtures

The flow value is influenced by asphalt content, aggregate distribution and compaction temperature. The Flow value can be seen in Table 6 and Fig. 8. Marshall Filler Cement results compared to Limestone, from the test results showing the flow value with variations in the addition of EVA + Binding Wire, that the more EVA + Binding Wire content in the asphalt concrete mixture, the melting value (flow) increases.

Table 6. Marshall flow of Modified Permeable Superpave Mixtures with cement and limestone fillers

Composition	Flow (mm)	
	Cement	Limestone
E0B0	2.28	2.26
E0B2	2.80	2.52
E0B4	3.47	2.75
E0B6	3.72	3.12
E0B8	3.77	3.35
E1B0	2.88	2.35
E1B2	3.42	2.73
E1B4	3.68	3.03
E1B6	3.72	3.27
E1B8	3.77	3.47
E3B0	3.02	2.63
E3B2	3.20	2.87
E3B4	3.38	3.17
E3B6	3.43	3.40

E3B8	3.68	3.57
E5B0	3.20	3.00
E5B2	3.40	3.22
E5B4	3.60	3.43
E5B6	3.80	3.55
E5B8	3.90	3.70

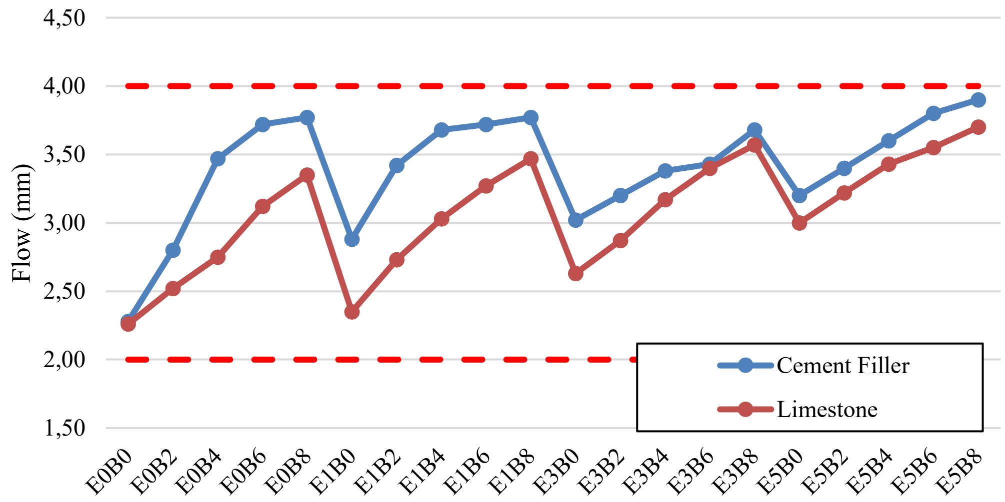

Fig. 8. Marshall flow Comparison between cement and limestone filler mixtures

From the test results, it shows that Portland cement filler tends to make the mixture stiffer, which can reduce the flow value if the content is too high, but still meets the specification standards (min. 2 mm or 3 mm depending on the type of mixture), on the other hand, Limestone Filler tends to produce a lower flow value (more flexible) than Portland Cement because of its grain characteristics that increase workability. The optimum flow value of the EVA 5% + BW 8% mixture with Cement is 3.90 mm. While the optimum flow value of the EVA 5% + BW 8% mixture with Limestone is 3.70 mm. The overall results of the Flow Value of each mixture have met the requirements of the 2025 Highway Engineering Specification [7].

3.4. Permeability Test

Permeability is the ability of a porous medium to flow fluid. Any material with empty spaces between them is called porous, and if the empty spaces are interconnected then it will have the property of Permeability. So, rocks; concrete; soil; and many other materials can be porous and Permeable materials. Materials with larger empty spaces usually have a larger pore number [14]. The Permeability Coefficient of asphalt is calculated based on Darcy's Law. The method for measuring the amount of Permeability is the falling head permeability (FHP) where the water in the tube (stand pipe) falls freely from a certain height until it passes through the cavity in the porous asphalt mixture. Another method for measuring Permeability is the constant head permeability (CHP) [15].

The results of the permeability test are in the table below and there is also a graph of all the Permeability parameter values, namely Dry Density and Velocity Coefficient (T = 28). For the results obtained from the mixture of Binding Wire ± 2 cm and EVA (Ethylene Vinyl Acetate) with limestone compared to Superpave asphalt Binding Wire ± 2 cm and EVA (Ethylene Vinyl Acetate) with Portland cement.

3.4.1. Dry Density of Modified Permeable Superpave Mixtures

Dry Density is a measure of the mass per unit volume of a compacted asphalt mixture. The Dry Density value reflects the compaction of the aggregate and asphalt mixture after the compaction process, which is important for determining strength, deformation resistance, and watertightness. The results are presented in Table 7 and Fig. 9.

Table 7. Dry Density of Modified Permeable Superpave Mixtures with cement and limestone fillers

Composition	Dry Density	
	Cement	Limestone
E0B0	0.86	0.86
E0B2	0.87	0.86
E0B4	0.88	0.87
E0B6	0.89	0.88
E0B8	0.90	0.89
E1B0	0.89	0.87
E1B2	0.88	0.88
E1B4	0.89	0.88
E1B6	0.90	0.88
E1B8	0.91	0.90
E3B0	0.89	0.88
E3B2	0.88	0.88
E3B4	0.89	0.88
E3B6	0.90	0.89
E3B8	0.91	0.90
E5B0	0.89	0.88
E5B2	0.88	0.88
E5B4	0.89	0.89
E5B6	0.90	0.89
E5B8	0.92	0.90

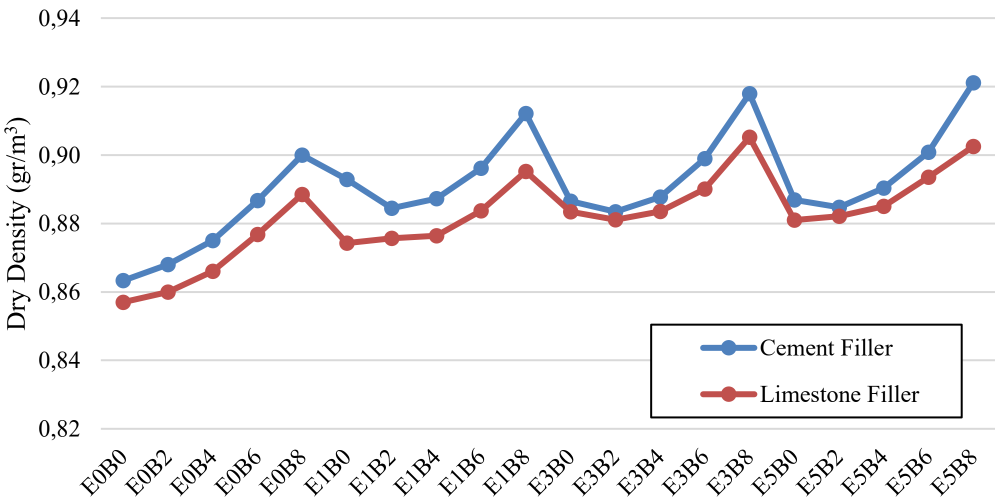

Fig. 9. Dry Density Comparison between cement and limestone filler mixtures

The test results show that the optimum Dry Density Value of the EVA + Binding Wire mixture occurs at an EVA content of 3% + BW 8% Cement Filler, which is 0.92 gr/cm2. While the optimum Dry Density Value for an EVA content of 5% + BW 8% Limestone Filler is 0.90 gr/cm2. The overall results of the Dry Density Value of each mixture have met the requirements of the Standard Test Method for Permeability of Asphalt (ASTM 2434 – 68) [16].

3.4.2. Permeability Coefficients of Modified Permeable Superpave Mixtures

The coefficient of permeability is influenced by asphalt cohesion, asphalt content, friction (internal friction), interlocking properties of aggregate particles, shape and surface texture, and aggregate gradation. The value of the coefficient of permeability can be seen in Table 8 and Fig. 10.

From the test results, it shows that Portland cement filler generally provides a higher Permeability Coefficient value than limestone due to its Permeability properties. The optimum Permeability Coefficient value of the EVA + Binding Wire mixture occurs at 3% EVA content + 8% BW Cement Filler, which is 1.48076×10^{-5} cm/second. While the optimum Permeability Coefficient. value for 0% EVA content + 8% BW Limestone Filler is 1.645×10^{-5} cm/second. The overall results of the Permeability Coefficient value of each mixture has met the requirements of the Standard Test Method for Permeability of Asphalt (ASTM 2434 – 68) [16] specifications.

Table 8. Permeability Coefficient of Modified Permeable Superpave Mixtures with cement and limestone fillers

Composition	Permeability coefficient ($\times10^{-5}$ m/s)	
	Cement	Limestone
E0B0	0.9039	0.9684
E0B2	1.0460	1.1410
E0B4	1.4810	1.6450
E0B6	1.2920	1.4530
E0B8	1.2080	1.3710
E1B0	0.6779	0.7395
E1B2	0.8365	0.9295
E1B4	1.2340	1.3880
E1B6	1.1070	1.2570
E1B8	1.0570	1.2080
E3B0	0.5423	0.6026
E3B2	0.6971	0.7842
E3B4	1.0580	1.2010
E3B6	0.9687	1.1070
E3B8	0.9394	1.0790
E5B0	0.4519	0.5084
E5B2	0.5975	0.6783
E5B4	0.9255	1.0580
E5B6	0.8610	0.9893
E5B8	0.8454	0.9394

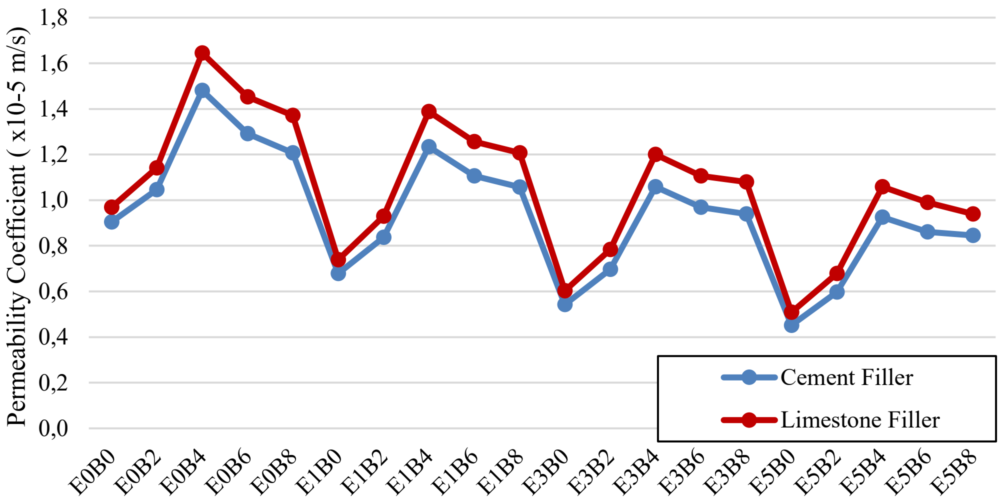

Fig. 10. Permeability Coefficient Comparison between cement and limestone filler mixtures

4. Conclusion

In the Superpave gradation type asphalt concrete layer testing with the addition of EVA (Ethylene Vinyl Acetate) and Binding Wire materials, data analysis was conducted and research results were obtained. Based on the objectives of the research, the following conclusions were obtained:

1. In a Job Mix Design study using EVA (Ethylene Vinyl Acetate) material compositions of 0%, 1%, 3%, and 5% and Binding Wire (Kawat Binding) of 0%, 2%, 4%, 6%, and 8%, all results from the study met the 2025 Bina Marga specifications, so this composition can be applied to road pavements.
2. Based on the results of the study, the test specimens experienced changes due to the addition of EVA (Ethylene Vinyl Acetate) and Binding Wire (approximately 2 cm) acting as reinforcing fibers (fiber reinforcement), which can increase the stability, durability, and stiffness of the asphalt mixture (Marshall Value) and potentially reduce permeability due to its properties that increase polymer bonds. It also increases resistance to cracking (fracture), but its application must be considered so as not to significantly reduce the density of the mixture.
3. From the results of the Marshall Test that has been carried out, the Marshall parameters obtained are the highest stability value obtained in the variation of EVA material 0% and Binding Wire 8% Portland Cement Filler of 2578.99 Kg. The highest Flow value was obtained in the variation of EVA material 5% and Binding Wire 8% Portland Cement Filler of 3.90 mm. The highest Marshall Quotient value was obtained in the variation of EVA material 0% and Binding Wire 8% Limestone Filler of 701.55%. The highest Void in The Mix (VIM) value was obtained in the variation of EVA material 2% and Binding Wire 5% Portland Cement Filler of 4.63%. Meanwhile, the highest Dry Density Permeability was at EVA 3% and Binding Wire 8% of 0.92 gr/cm^2 Portland Cement Filler and the highest Permeability Coefficient was at EVA 0% and Binding Wire 4% of 1.64528×10^{-5} gr / cm Limestone Filler.

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References

[1] Setyawan, A., Nainggolan, J., & Budiarto, A. (2015). Predicting the remaining service life of road using pavement condition index. *Procedia Engineering*, *125*, 417-423.

[2] Andry, J., Pratikso, P., & Mudiyono, R. (2023). *Perilaku Aspal Wearing Course terhadap Pengaruh Rendaman Air Pasang (ROB) dengan Bahan Tambah Polyethylene dan Fine Agregat Slag* [Performance of Asphalt Wearing Course Under Tidal Flood (ROB) Immersion Using Polyethylene Additive and Slag Fine Aggregate]. In *Prosiding Seminar Nasional Teknik Sipil UMS*, 187-192.

[3] Kliswanto, M. S., & Pradana, F. Y. (2023). *Analisis Perbandingan Aspal Wearing Coarse (Ac-Wc) Dengan Buton Granular Aspal (Bga) 15/20 Pada Penetrasi 60/70 Menggunakan Fly Ash Terhadap Uji Parameter Aspal* [Comparative Analysis of Asphalt Concrete-Wearing Course (AC-WC) and Buton Granular Asphalt (BGA) 15/20 at 60/70 Penetration Grade Using Fly Ash on Asphalt Parameter Tests] (Doctoral dissertation, Universitas Islam Sultan Agung Semarang).

[4] Asphalt Institute. (1995). *Asphalt Institute Superpave series no. 2 (SP-2): Superpave Level 1 mix design*. Lexington, KY.

[5] Strategic Highway Research Program (SHRP). (1996). *Superpave manual series 2 (SP-2)*. National Research Council.

[6] Zeiada, W., Liu, H., Ezzat, H., Al-Khateeb, G. G., Underwood, B. S., Shanableh, A., & Samarai, M. (2022). Review of the Superpave performance grading system and recent developments in the performance-based test methods for asphalt binder characterization. *Construction and Building Materials*, *319*, 126063.

[7] Direktorat Jenderal Bina Marga. (2025). *Spesifikasi umum bidang jalan dan jembatan Divisi 6 perkerasan beraspal* [General Specifications for Roads and Bridges Division 6 Asphalt Pavements]. Pusat Litbang Jalan dan Jembatan Badan Penelitian dan Pengembangan.

[8] Hartono, J., Wibowo, D. E., & Fajari, A. (2020). *Pengaruh Variasi Bahan Tambah Kawat Bendrat Dan Filler Abu Sekam Padi Pada Laston (AC-BC) Terhadap Karakteristik Marshall* [The Effect of Variations in Binding Wire Additives and Rice Husk Ash Filler on Asphalt Concrete-Binder Course (AC-BC) Against Marshall Characteristics]. *Orbith: Majalah Ilmiah Pengembangan Rekayasa dan Sosial*, *16*(2), 124-131.

[9] Rosyad, F., & Sary, D. D. (2017). *Pengaruh Penambahan Biji Plastik Sebagai Pengganti Fraksi Halus Terhadap Kepadatan dan Stabilitas Campuran Aspal AC-BC* [The Effect of Adding Plastic Pellets as a Fine Fraction Replacement on the Density and Stability of AC-BC Asphalt Mixtures]. *Jurnal Tekno*, *14*(1), 43-51.

[10] M. Alfarikhi et al, (2024). *Pengaruh Penambahan Batu Kapur Paciran Kabupaten Lamongan Sebagai Filler Terhadap Kinerja Campuran Asphalt Concrete Binder Course (AC–BC)* [The Effect of Adding Paciran Limestone from Lamongan Regency as Filler on the Performance of Asphalt Concrete-Binder Course (AC–BC) Mixtures]. *Jurnal Gradasi Teknik Sipil, 9*(2).

[11] Badan Standar Nasional. (1990). *Metode pengujian analisis saringan agregat halus dan kasar* (SNI 03-1968-1990) [Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates].

[12] Badan Standar Nasional. (1991). *Metode Pengujian Marshall* (SNI 06-2489-1991) [Standard Test Method for Marshall Properties of Asphalt Mixtures].

[13] Bayen, A. M. and Shaw T. (2014). An Introduction to Matlab Programing and Numerical Methods For Engineers, ISBN : 978-0-12-420228-3

[14] Bowles, E. J. (1986). *Sifat – Sifat Fisis Dan Geoteknis Tanah (Mekanika Tanah)* [Physical and Geotechnical Properties of Soil (Soil Mechanics)], Penerbit Erlangga. Jakarta Pusat.

[15] Kandhal, P. S. and Mallick, R. B. (1998) Open Graded Asphalt Friction Course State Practice. Aubum University, Alabama.

[16] ASTM International. (2000). *Standard test method for permeability of asphalt* (ASTM D2434-68).