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Functional Performance of Modified Porous Asphalt Mixtures with Gilsonite Additive

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ABSTRACT

Porous asphalt is an asphalt mixture with more voids than other asphalt mixtures of a surface layer of a typical flexible pavement structure. Porous asphalt mixtures have several advantages, namely the voids contained in the porous asphalt mixture function to help drain water vertically and horizontally, providing greater skid resistance. In addition to these advantages, the disadvantage of porous asphalt mixtures is the low stability value caused by the large number of voids in the porous asphalt mixture. Because porous asphalt mixtures have many advantages, to increase the stability value of porous asphalt mixtures, one of the methods used is by adding gilsonite. The method used in this research is an experimental method with a laboratory scale. The tests carried out in this study were in the form of skid resistance tests. The porous asphalt mixture in this study used 2 gradations, namely Japanese and Australian gradations. The test specimens used in this mixture are mixtures with optimum asphalt content and 0% gilsonite content. While the modified porous asphalt pavement is a mixture of gilsonite and pen 60/70 asphalt with gilsonite content and optimum asphalt content of 5.5% each. The results showed that the functional performance improvement of the modified asphalt pavement for Japanese and Australian gradations was 14.5% and 2.7%, respectively. Thus, there is an increase in the magnitude of skid resistance values from 55 BPN to 63 BPN and from 75 BPN to 77 BPN or by 8.0 BPN and 2.0 BPN for Japanese and Australian gradations, respectively. This increase in skid resistance value will provide a better level of safety for vehicle users.

I. Introduction

Porous asphalt mixtures have high air voids and a small proportion of fine aggregate. The high air voids are caused by the gradation of the porous asphalt mixture, which is open-graded. The air/pore space is a dual drainage system that can drain water vertically and horizontally. A porous asphalt mixture is a pavement mixture that is planned to be a mixture that is laid and compacted to form a surface with a ratio of voids in the mix of around 22%. [5]

Porous asphalt is used as a surface course and is always placed on top of an impermeable layer. Porous asphalt mixtures are designed to have interconnected voids with high permeability. Thus, water can quickly enter the pavement and transfer from the surface to the shoulder. The ability of porous asphalt as a drainage system can reduce pavement life. Aggregation of small objects and dust in the surface voids can reduce the ability to flow water. Porous pavement structures are a new technology built for low-traffic volume road sections, vehicle parking facilities, bicycle lanes, pedestrian facilities/sidewalks, and tennis courts as an alternative to water management techniques or superior management practices. [7]

The porous asphalt mixture can be the surface layer of a flexible pavement structure that is environmentally friendly and is very good for use in vehicle parking areas, hereinafter known as part

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of the porous pavement structure.[4] The U.S. Department of Transportation and the Federal Highway Administration (FHWA) recommend that porous pavement structures consist of 3 (three) layers, namely surface layer, filter layer, and reservoir layer, all built on permeable subgrade.[7] Meanwhile, the method for planning porous pavement structures for river gems was published in 1977 by researchers from the Franklin Institute Research Laboratories in Philadelphia.[4][7]

Porous asphalt mixtures are different from Asphalt Concrete-Wearing Course (AC-WC) pavement mixtures in general. This can be seen from the test results carried out by Riski [6] showing that the stability values and marshal parameters occupy the requirements for the pavement mixture. Many improvements have been made to the performance of porous asphalt mixtures, namely by adding certain ingredients to the porous asphalt mixture. The efforts made can include the type of aggregate used, the type of binder and the addition of a substance to the porous asphalt mixture. Efforts to increase the Marshall stability value by adding a substance to the porous asphalt mixture have been carried out by several researchers. The additional ingredients used are also varied.

Wang Y., and Wang G., [10] conducted research on porous asphalt mixtures by adding Recycle Asphalt Shingle. The results of this research show that the performance of the porous asphalt mixture as shown by the rutting parameter gives a value of 4.287 mm in a test of 8,000 load cycles at a temperature of 64°C. Meanwhile, the addition of granite and steel slag respectively produced rutting of 6.0 mm and 2.0 mm. Furthermore, additional material in the form of recycled tire rubber into the porous asphalt mixture provides a greater rutting value, namely 9.318 mm. The limit for rutting is 7.0 mm to 8.0 mm. [8]

Further research into the performance of porous asphalt mixtures has been carried out, namely by adding gilsonete. The results of this research show that gilsonite can improve the quality of the mixture characteristics, such as reducing the magnitude of rutting due to loading, reducing sensitivity to temperature and the effect of water immersion, and can produce good bonds between aggregates (Road Research and Development Center, 1993).

Research on the effect of additives on the marshall performance of porous asphalt mixtures by comparing additives between gilsonite and latex. This research was designed by varying the levels of gilsonite and latex and then analyzing which additives produce high stability values. The results of the study obtained a flow discharge value of porous asphalt mixture with gilsonite additives of 910 cm^3 /second, the stability obtained was 937 kg with an optimum gilsonite content of 9%, while the stability value of porous asphalt mixture with latex additives obtained a flow discharge of 1024 cm3 /second, a stability of 627 kg and an optimum latex content of 2%. [2]

Previous research also evaluated the performance of porous asphalt using 3 gradations, namely Australian, California, and British. In terms of characteristic specifications, the Australian standard was used. Twelve test specimens were made per gradation with variations in asphalt content between 4% - 7%. The optimum asphalt content was obtained to make 12 test specimens with Wetfix-Be additive. The Wetfix-Be content used ranged from 0.2% - 0.5%. The specimens were used for permeability testing using the falling head method. The study's results using 3 gradations can be concluded that the Australian standard produces higher permeability coefficient values than California and British. Standard Marshall characteristics, namely VIM, Flow, and MQ of Australian and California standards, meet the requirements, while stability does not. These results are inversely proportional to the Marshall characteristics generated from the British standard. [12]

Although much research has been done on the characteristics and performance of porous asphalt mixtures with the addition of certain ingredients, their application in porous pavement structures as a surface layer is still limited to parking lots or roads with low traffic volumes. Furthermore, one of the main problems with porous pavement structures, especially surface layers, is their durability and strength characteristics.[7] One of the main failures associated with porous pavement structures is due to lack of stiffness of the binder. [4]

Based on this research, it is recommended to limit the use of additives and reduce the gilsonite content because it affects the VIM and permeability values of the mixture. In addition, further research needs to be carried out by modifying the gradation of the mixture used. Additional field testing is required so that the performance and permeability of the mixture can be obtained properly. As for efforts to implement the suggestions from the research, the following research is to reduce the level of gilsonite, using variations in gradation based on Australian and Japanese standards. The follow-up research was conducted using Australian gradation based on the Australian Asphalt Pavement Association (AAPA) 2004 and Japan Road obtained an optimum asphalt content of 5.5% with a low mixture void value. [10]

Further research was developed to determine the performance of porous asphalt mixtures used as pavement. The performance of the pavement structure is divided into two, namely structural performance and functional performance. Structural performance is based on the strength of the flexible pavement structure in accepting the cumulative load of vehicles during the service life. In contrast, functional performance is reviewed based on road users' comfort or safety level. Functional performance analysis on a pavement structure often uses the International Roughness Index (IRI) parameter, or in the design of a flexible pavement structure, the AASHTO method uses the Present Serviceability Index (PSI) parameter/surface index. The value of these parameters can show the level of comfort that road users can feel. However, in this research, the functional performance analysis will not discuss IRI or PSI but the functional performance will be discussed in terms of road user safety obtained from the results of the skid resistance test. Skid resistance is the force generated between the road surface and vehicle tires to compensate for the vehicle's forward motion when braking. The surface texture depth of the pavement influences the value of skid resistance. This study aims to determine the value of skid resistance, the value of surface texture depth of flexible pavement, and the correlation between the two. The value of skid resistance influenced by the use of gradation and gilsonite additives will be compared in terms of comfort based on existing standards.

II. Method

The materials (fine and coarse aggregate) used in this research came from Cagak, Subang, West Java. The asphalt used is *Pertamina* asphalt with a penetration of 60/70. Aggregate and asphalt testing based on *Rancangan 2 Indonesia* for porous asphalt mixtures. Furthermore, the additional material used in the asphalt mixture is gilsonite which was ordered from a distributor originating from Bandung as seen in Figure. 1.

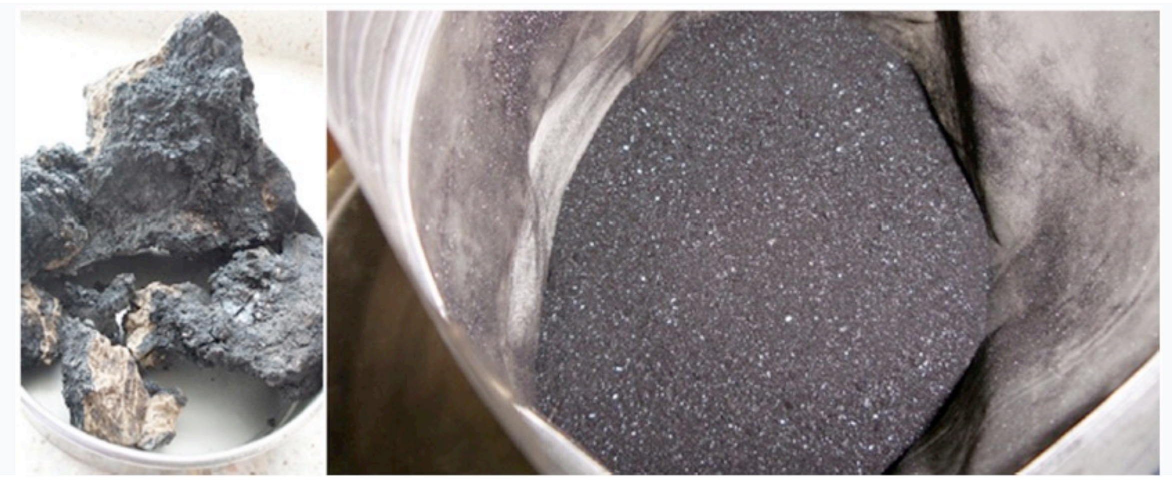

Fig. 1. Before and After Grinding of Gilsonite
source: Hugo Alexander (*ASCE*)

For planning the aggregate gradation of the porous asphalt mixture that will be used is the middle gradation limit of Australia [1] and Japan [3] as seen in Table 1.

Table 1. Gradation of Porous Asphalt

Diameter Saringan (mm)	Gradasi Australia	Gradasi Jepang
	Diameter Agregat	% Agregat Lolos
	14 mm	
19.0	100	100
12.7	85-100	92-100
9.53	45-70	62-81
6.70	25-45	-
4.760	10-25	10-31
2.380	7-15	10-21
1.190	6-12	-
0.595	5-10	4-17
0.297	4-8	3-12
0.149	3-7	3-8
0.074	2-5	2-7
Total	100	100
Kadar aspal	4,5-6.0	

Source: AAPA and Japan Road

The surface layer materials of the pavement structure to be used are porous asphalt without gilsonite additives, which are now referred to as conventional porous asphalt and modified porous asphalt using Japanese and Australian gradation. Conventional porous asphalt pavement used in this mixture is a mixture with optimum asphalt content and 0% gilsonite content. The modified porous asphalt layer is a mixture of gilsonite and pen 60/70 asphalt with gilsonite content and optimum asphalt content of 5.5% each. [9]

The test object used in the skid resistance test measures 30 x 30 x 5 cm, as shown in Fig 2. The skid resistance test is carried out on the surface and does not damage the test object. The test was conducted at 3 points: 2 cm from the left side edge, 15 cm from the left/right edge, and 2 cm from the right side edge, with a surface temperature of 27°C.

Fig. 2. Test Objects on Wheel Tracking Device

The skid resistance value of the pavement surface is measured using the British Pendulum Tester (BPT), which is based on SNI 4427: 2008 [8], as shown in Fig. 3.

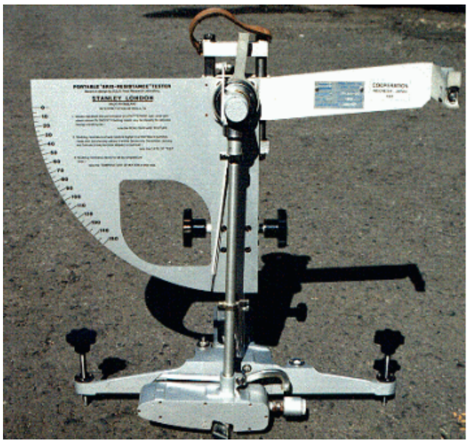

Fig. 3. British Pendelum Tester (BPT) Test Equipment [8]

The skid resistance value in British Pendulum Number (BPN) units is obtained from the test results. Based on Road Research Laboratory (1996), the minimum skid resistance value is categorized into three, as shown in Table 2.

Table 2. Minimum Skid Resistance Value Using British Pendulum Tester

Categories	Location Types	Minimum skid resistance value
A	Difficult locations such as:	65
	Roundabouts; turns <150 m in radius on freeways; gradients of 1:20 or steeper, >100 m in length; approach arms of signalized intersections on freeways.	
B	Major/fast, continuous and class 1 roads and heavy traffic roads in urban areas (>2000 vehicles per day)	55
C	Other locations	45
Note:	For categories A and B where vehicle speeds are high (>95 km/h) additional requirements are a minimum texture depth of 0.65 mm.	

Sumber: Road Research Laboratory (1969)

III. Results and Discussion

The test was conducted by comparing the use of two different gradations, Japan and Australia. Table 3 shows the skid resistance test result of the porous asphalt mixture.

Table 3. Skid Resistance Testing Results

No.	Mixture Types	Gradation Types	BPN Score
1	Gs 0% ; KAO 5,5%	Jepang	55
2	Gs 5,5% ; KAO 5,5%		63
3	Gs 0% ; KAO 5,5%	Australia	75
4	Gs 5,5% ; KAO 5,5%		77

Based on the test results in Table 2, the BPN values of both gradations are between 55 and 77. When compared with the existing standards, as in Table 1, the skid resistance produced from both gradations, both without and using gilsonite additives, still meets the standards of the three categories of Road Research Laboratory (1996).

IV. Conclusion

Based on the research that has been done, the following conclusions can be drawn, namely:

1. The increase in skid resistance value is from 55 BPN to 63 BPN and from 75 BPN to 77 BPN or by 8.0 BPN and 2.0 BPN for Japanese and Australian substations, respectively.
2. Functional performance of modified porous asphalt for Japanese and Australian gradations improved by 14.5% and 2.7%, respectively. Thus, the magnitude of the skid resistance value increased from 55 BPN to 63 BPN and from 75 BPN to 77 BPN or by 8.0 BPN and 2.0 BPN for Japanese and Australian substations, respectively. This increase in skid resistance value will provide a better level of safety for vehicle users.

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