Mechanical properties of porous asphalt with gilsonite additive

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Abstract. The porous asphalt mixture is an asphalt mixture that consist of high void and a small proportion of fine aggregate. The presence of a high void reduces the value of marshall stability. Many attempts to increase the value of marshall stability by adding substances into the porous asphalt mixture has been done by several researchers. Modified porous asphalt can be achieved by adding gilsonite to the mixture which aims to accomplish the main function of the porous asphalt layer as well as to improve the quality of mixed performance. The method used in this study is an experimental method. The test that conducted in this study using two types of gradations that are Japan and Australia gradation. The research was Marshall characteristic test with 2.5%, 3.5%, 4.5%, 5.5%, 6.5% of gilsonite content and 0% as the control. The results showed that porous asphalt mixture using gilsonite proved to increase the value of Marshall stability compared to non-modified porous asphalt mixture by 24%. The mixture reaches a maximum state at 5.5% gilsonite content. The best performance is produced by the mixture using Japanese gradation.

1. Introduction

The porous asphalt mixture has a high void and a small proportion of fine aggregate. The high airspace caused by the gradation on the porous asphalt mixture is open graded. The air / pore space itself serves as a dual-drainage system that can drain water vertically or horizontally. The porous asphalt mixture is a planned pavement mixture which is laid and compacted to form a surface with a void ratio in the mixture of 22% [1].

The asphalt porous has several advantages as follow: the void contained in the porous asphalt serves to help drain the water vertically and horizontally, providing greater skid resistance, reducing the noise level for users and the surrounding, and it can also improve the safety for the road users [2]. Furthermore, porous asphalt can be used as a reservoir medium that can drain and store rainwater into the soil. In addition to these advantages, the disadvantage which is the main constraint on porous asphalt mixture is the low value of stability caused by the number of void on the porous asphalt [3].

An attempt to increase the value of marshall stability by adding a substance into the porous asphalt mixture has been done by several researchers. There are various supporting materials used, namely; Elvaloy, TAFPACK-Super, Latex, Gilsonite, and so on. The performance research on porous asphalt mix has been done by the Puslitbang Jalan in 1993 by adding gilsonite. The results show that gilsonite can improve the quality of mixed characteristics, such as reducing the value of rutting caused by the loading, reducing sensitivity to temperature and the effect of water immersion, and it can produce good bonds between aggregates. Furthermore, Djakfar et al. has compared the effect of adding gilsonite and
latex as an additive to Marshall performance on porous asphalt mixtures [4]. The results obtained that the mixture of porous asphalt with the supporting materials of gilsonite proved to increase the value of marshall stability, compared with latex added ingredients. However, the addition of gilsonite may affect the void in the mixture.

Based on these results, the research will be used as an additional material in the asphalt mixture by reducing the percentage that aims to achieve the function of the asphalt layer and improve performance in parameters.

2. Methods

2.1. Materials

The material (fine and coarse aggregates) used in this study came from Cagak, Subang, West Java. Furthermore, the asphalt used is Pertamina asphalt with penetration of 60/70. The test of aggregate and asphalt is conducted based on Rancangan 2 Indonesia for porous asphalt mixture. Furthermore, the additional ingredients used in the asphalt mixture are gilsonite ordered from distributors originating from Bandung as shown in Fig. 1.

![Gilsonite before and after milling.](image1.png)

**Figure 1.** Gilsonite before and after milling.

2.2. Machine and specimens

The test specimens used in this study is the middle border of two gradations, which are Japanese gradation and Australian gradation. The variations of asphalt content used are 4.5, 5.0, 5.5, and 6.0%, while the gilsonite content variation is 0, 2.5, 3.5, 4.5, 5.5, and 6.5%. Each level consists of 3 pieces of the specimen. The test is a Marshall characteristic test to obtain stability, VIM, and flow by using the tool as shown in Fig. 2. The results of this test are compared with the specifications of Rancangan 2 Indonesia, Australian Asphalt Pavement Association (AAPA) 2004, and Japan Road.

![Marshall machine.](image2.png)

**Figure 2.** Marshall machine.
3. Results and discussion

In accordance with Rancangan 2 Indonesia, the aggregates and asphalt used in the research have met the characteristic testing requirements.

The test results of Marshall characteristics obtained from this research are in the form of stability, VIM, and flow.

![Figure 3. Void In Mixture (VIM) of Japanese gradation.](image)

Fig. 3 the picture shows that the addition of gilsonite causes the VIM values from the Japanese gradations has an improvement. The increase occurred at 5.5% gilsonite.

![Figure 4. The Australian gradation test mixture.](image)

Fig. 3 the picture shows that the void in the Japanese gradation test mixture inversely proportional to the VIM value of the Australian gradation test mixture in Fig. 4. The VIM values produced by the Japanese graded mixture have a lower value than the Australian gradation test mixture. However, the value does not meet the specification because the VIM value of the two gradations is still below the specifications that have been written in Rancangan 2 Indonesia and AAPA 2004. As for Japan Road itself, it has no specification about the void in the mix.
According to Fig. 5, the Marshall stability value resulted in Japanese gradation shows the same thing as the VIM test results. A stability value that is greater than 500 kg occurs in gilsonite 5.5%.

The stability of the Japanese gradation test mixture in Fig. 5 has a higher value than a mixture of Australian gradation test objects in Fig. 6. The stability value of all Japanese gradation test objects meets the Japan Road specification of at least 350 kg [5], while the stability value of the Australian gradation test mixture does not meet the AAPA 2004 specification of at least 500 kg [6]. The value of the stability is related to the void in the mixture of the specimen. It means that, the smaller the value of the void, the better the resulting density, so the better the resulting stability.
Based on Fig. 7 and Fig. 8, all flow values generated from Japanese and Australian gradation test mixtures meet the specified specifications of AAPA 2004 and Japan Road. The flow value is within the range specified in AAPA 2004 which is 2 - 6 mm [6] and Japan Road is 2 - 4 mm [5]. Using the approach of examination of Marshall characteristics, the optimum gilsonite content obtained was 5.5%. The characteristic quality of the content is then compared with the control specimen as shown in Fig. 9 - Fig. 11.

The results of the void testing in the mixture using the optimum gilsonite content in Fig. 9 shows that the void in the Japanese and Australian gradation test mixture still do not meet the specifications set out in Rancangan 2 Indonesia and AAPA 2004, while Japan Road does not have specifications for void in mixture. The void in the Japanese gradation test mixture has a lower than the Australian gradation test object. This happens because Japanese gradation is smoother than Australian gradation, so the void produced by Japanese gradation is less than Australian gradation.

The presence of gilsonite has been shown to affect the void in the mixture. The void in the modified mixture is decreased. This is consistent with the results of the Djakfar et al. study, but the VIM obtained in this study has improved from the Djakfar et al., study.
Fig. 10 shows that the stability value from the Japanese gradation test mixture has a higher stability value than the Australian gradation test object. The value of the stability of Australian gradation test objects does not meet the AAPA specification of 2004 which is at least 500 kg, while the stability value of Japanese gradation test objects meets the Japan Road specification of at least 350 kg. However, if the stability value of Japanese and Australian gradation test objects is compared with the specifications of Rancangan 2 Indonesia, the Japanese and Australian grading objects have met the minimum of 350 kg [7] specifications.

Marshall stability is a parameter of mixed strength image to the acceptable load. The stability associated with the void in the mixture. The smaller the void, the greater the resulting stability value. The addition of gilsonite in asphalt modification proved to increase the value of stability, this result is in accordance with the study of Djakfar et al.

Flow is a parameter that serves to determine the elasticity or change in the plastic form of asphalt mixture due to workload. Low melting values indicate a good resistance to deformation.

The flow value in Fig.11 shows that the Japanese gradation test mixture has a smaller value than the Australian gradation test mixture. However, the mixture of test specimens with the gradations of Japan and Australia has met the specifications determined by Japan Road and AAPA 2004 which are respectively 2 - 4 mm and 2 - 6 mm.

From the overall characteristic testing, Japanese gradation showed better performance than Australian gradation and in summary as shown in Table 1.
Table 1. Resume of Japan characteristic.

| Parameter  | Specification of Japan Road | Gilsonite Content (%) | Notes |
|------------|-----------------------------|-----------------------|-------|
|            |                             | 0                     | 5.5   |       |
| VIM (%)    | -                           | 13.08                 | 14.16 | Increase 8% |
| Stability (kg) | >350                  | 404.65                | 500.49| Increase 24% |
| Flow (mm)  | 2-4                        | 4.17                  | 4.33  | Increase 4%  |

4. Conclusion
From the result of the research, it can be concluded that:
- The addition of gilsonite in the asphalt has proved to improve the quality of mixed characteristics on some parameters, i.e. stability, the mixture cavity, and flow.
- The mixture reaches a maximum state at 5.5% gilsonite and 5.5% bitumen content.
- The overall parameter of mixed test results using Japanese gradation has a better value than the mixture by using Australian gradation. Thus, the mixture by using Japanese gradation yields better stability than the mixture using Australian gradation.

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