Deformation and dynamic stability of asphalt concrete by using granite dust as filler

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Abstract. Asphalt Concrete – Wearing Course (AC-WC) is a surface layer of flexible pavement which have direct contact with vehicle wheel. One of the surface layer damage categories is the wheel track (rutting). In this research, the experiment was done by using industrial waste of granite stone production in the form of dust as filler in the AC-WC mixture. The variation of filler content used are 3%, 4.5%, 6%, 7.5% and 9% with cement filler as comparator. The test was conducted by using wheel tracking machine on temperature of 60˚C, 45˚C and 30˚C. The test result shows that the optimum filler content using granite dust in the AC-WC mixture is 3%. Meanwhile the optimum filler content on the asphalt concrete using cement filler is 7.5%. Thus, it shows that the higher temperature cause the ability of maintaining the wheel track decreased. Furthermore, if looking at the relation between dynamical stability, deformation depth and deformation velocity on filler concentration is not linear.

1. Introduction

Asphalt concrete - wearing course (AC-WC) is a surface layer of flexible pavement have direct contact with vehicle wheel; wherein, the asphalt concrete mixture comprises coarse aggregate, fine aggregate, filler and asphalt as the binding agent. In general, the material used as a filler in the AC-WC mixture is cement, limestone, dolomite, fly ash and others. The function of the filler in the asphalt concrete mixture is as a filler between the coarser aggregates meaning that the air cavity (void) becomes small, and can produce frictional resistance and locking between the higher bonds.

Chandra states that the AC-WC mixture with granite dust as a filler has better rutting resistance compared to regular stone dust [1]. Asphalt concrete with granite filler has a better fatigue resistance when compared to ordinary stone dust. The asphalt concrete mixture with granite dust as filler shows the linear bitumen content of the filler content. The higher theu filler level will cause the optimum bitumen content becomes lower, because the asphalt will be absorbed by the filler. According to Fasadaryah, a mixture of AC-WC with granite dust as filler meets the Bina Marga 2010 specification [2].

Furthermore, Widodo states that the more solid AC-WC will cause the ability to maintaining the trace of the wheels better [3]. The higher the temperature will cause a decrease of the AC-WC capability in holding the trace of the wheels.

Based on the description above, the research on the use of granite ash waste as a filler on AC-WC mixture is done with variations of filler content of 3%, 4.5%, 6%, 7.5% and 9%. The determination of variation of filler content based on value of filler level has not been done by previous researcher Chandra [1] and Fasadarsyah [2].

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2. Methodology

2.1. Material
The material used in this study is shown in Fig. 1; The coarse aggregate and fine aggregate originated from around West Bandung; whereas, for granite ash filler comes from Ketapang District of West Kalimantan Province, as well as Pertamina asphalt with penetration 60/70. All materials are tested based on the technical specifications of Bina Marga in 2010 revision III.

![Figure 1. Materials: (a), (b) coarse aggregate; (c) fine aggregate; (d) granite dust.](image1)

2.2. Machine and specimen
This study is begun with testing of all materials based on the 2010 Bina Marga specification of revision III [4]. Subsequently, the test object is made and tested by Marshall method as shown in Fig. 2. Marshall test is done to get the optimum bitumen content which will be used for making Wheel tracking machine (WTM) test specimen [5].

![Figure 2. (a) Specimen; (b) Marshall testing.](image2)

To obtain deformation behavior and dynamic stability on AC-WC surface layer with granite dust, thus it was tested by using Wheel tracking machine. Square test object with size 30 x 30 x 5 cm, Wheel tracking machine run with speed 21 passing / minute. The tests are carried out at temperatures 60°C, 45°C and 30% °C for 1 hr and tracing observations are performed on the 21st, 105, 210, 315, 945, and 1260 passing [6]. Fig. 3 shows the equipment for the manufacture and testing of deformation and dynamic stability of the AC-WC.
Figure 3. (a) Mixing machine; (b) Compactor machine; (c) Specimen; (d) Wheel tracking machine.

From the test results using the tool Wheel tracking machine shows that the test object is deformed as shown in Fig. 4.

Figure 4. (a) AC-WC with filler granite; (b) AC-WC with filler cement

3. Test result

3.1. Optimum bitumen content

From the results of Marshall testing, we get the optimum bitumen content for each filler content as shown in Table 1.

| Filler content | Granit dust | Cement |
|----------------|-------------|--------|
| 3%             | 6.23%       | 6.20%  |
| 4.50%          | 6.17%       | 6.18%  |
| 6%             | 6.15%       | 6.16%  |
| 7.50%          | 6.1%        | 6.1%   |
| 9%             | 5.9%        | 6.09%  |
Table 1 indicates that the larger the filler content will cause the value of the optimum bitumen content to be smaller because empty cavities on the asphalt concrete have been filled by the filler.

3.2. Structural performance

The results of testing with Wheel tracking machine tool will get the value of dynamic stability, deformation velocity and deformation depth. The deformation occurring on the pavement is one of the parameters in the assessment of pavement performance.

In this research, deformation and dynamic stability testing is done with pavement temperature variation. The temperature of the 60°C test is the most extreme temperature of the pavement, which describes the pavement conditions during the day. Temperature 45°C as a picture of the temperature of the pavement between morning and noon and noon and afternoon. While temperature 30 °C is a picture of the temperature of pavement in the morning and evening.

**Figure 5.** The relationship of dynamic stability with variations of filler content at 60°C.

Fig. 5 shows the relationship of dynamic stability values between asphalt concrete with the content of cement filler and granite filler at 60°C pavement temperature. The picture shows that the relationship of dynamic stability to filler content is not linear; as well as the type of filler. In general, asphalt concrete with cement filler has a greater stability value than asphalt concrete with granite filler. The use of a 7.5% cement filler achieves the highest dynamic stability value, ie 2520.0 passing/mm. Meanwhile, asphalt concrete with granite filler with 3% filler content achieved the highest dynamic stability value, ie 1465.1 passing/mm; which is higher than the achievement of cement filler of the same degree (1400 passing/mm). The addition of filler beyond the optimum level will decrease the value of dynamic stability because it will reduce the contact between coarse aggregate particles [7].

**Figure 6.** Deformation depth relationship with variation of filler content at temperature 60°C.
Fig. 6 shows the depth of deformation that occurs on the pavement with a temperature of 60°C. The picture shows that the deformation depth that occurs is not linear to the filler content, nor the filler type. For pavement with cement filler, the smallest deformation (2.01 mm) occurs at a 7.5% filler level. While on the granite filler pavement, the smallest deformation (2.42 mm) occurs at 3% filler content.

![Deformation velocity chart](chart.png)

**Figure 7.** The relationship of deformation velocity with variation of filler content at temperature 60°C.

Fig. 7 shows the relationship between deformation velocity on asphalt concrete with cement filler and granite filler at 60°C pavement temperature. The picture shows that the relation of deformation velocity to filler content is not linear; as well as the type of filler. For the smallest deformation speed (0.0167 min / mm) occurs in asphalt concrete with cement filler, at a 7.5% filler content. While the asphalt concrete with the granite filler variation the smallest deformation velocity (0.0287 min / mm) occurred at 3% filler level. The smaller the speed of deformation will cause the value of dynamic stability which is greater meaning that the depth of deformation becomes small.

Tests of deformation and dynamic stability are carried out with temperature variations of 60°C, 45°C and 30°C as shown in Fig. 8.

![Dynamic stability chart](chart.png)

**Figure 8.** The relationship of dynamic stability with filler content to temperature variation on asphalt concrete with granite filler.
Fig. 8 shows the relationship between dynamic stability and granite filler content to temperature variations. The picture shows that the higher the temperature will cause a decrease of value of dynamic stability on the pavement. The decrease in the value of dynamic stability is due to the highly sensitive nature of the asphalt to the change of the temperature.

**Figure 9.** The relationship of dynamic stability with filler content to temperature variation on asphalt concrete with cement filler.

Fig. 9 shows the relationship between dynamic stability and filler levels against temperature variations. With the increase of cement filler content on the pavement, it will increase the value of dynamic stability, but after reaching optimum filler level (7.5%) the value of dynamic stability will decrease again. The higher the temperature will cause the value of dynamic stability to decrease.

**4. Conclusion**

Based on the results of the research, it can be concluded several things as follows:

- The larger the filler content will cause the value of the optimum bitumen content to be smaller, because the empty cavities in the asphalt concrete mixture are already filled by the filler.
- The relationship of dynamic stability, deformation and deformation velocity to filler content is non-linear.
- The higher the temperature on the pavement, will cause the value of dynamic stability to decrease.
- The use of cement filler with 7.5% content reaches the highest dynamic stability value, ie 2520.0 passing / mm. Meanwhile, asphalt concrete with granite filler with 3% filler content reached 1465.1 passing / mm.
- On asphalt concrete with variation of cement filler content, the smallest deformation (2.01 mm) occurs at 7.5% filler level. While on asphalt concrete with variation of granite filler content, the smallest deformation (2.42 mm) occurred at 3% filler content.
- The smallest deformation speed (0.0167 min / mm) occurs in asphalt concrete with cement filler, at 7.5% filler content. While the asphalt concrete with the granite filler variation of the smallest deformation velocity (0.0287 min / mm) at 3% filler content.
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