The Effect of Beach Sands to Replacement of Fine Aggregate with Addition Filler of Ash Cane on the Asphalt Mixture on Marshall Characteristics

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Abstract. The purpose of this research is to know the effect of beach sand as a substitute for river sand in a mixture of concrete asphalt against the characteristic values of the marshall and to determine the effect of adding sugarcane ash filler with the percentage of ash filler 0%, 5%, 10%, 15% on the concrete asphalt mixture against the characteristic values of the marshall. This research is an experimental study using fillers in the form of sugarcane ash filler with varying levels of variation in the amount of 0%, 5%, 10%, 15%. The specimens using AC-BC mixture was then tested using the Marshall method values of stability, density, flow, VIM, VMA, VFA, MQ. The results of this study indicate that the addition of sugarcane ash filler and the use of beach sand as a substitute for river sand affect the value of the characteristics of the marshall. The more filler levels used in the asphalt mixture, the greater the value of stability and MQ. While the flow value, density, VIM, VMA, VFA are getting smaller. Other factors that influence marshall characteristic values are asphalt content used, aggregate gradation, temperature in compaction, mix quality, and the process of mixing asphalt.

Keywords: asphalt, beach sand, sugarcane ash filler

1. Introduction
Roads have been a crucial transportation infrastructure that greatly influences the development of social and economic among the community since it provides the movement access for people and goods which are safely, comfortably, quickly and economically. In fact, the escalation number of vehicles is not followed by road improvements so it is found many damages. The causes of road damage are due to excessive repetitive traffic loads, heat/air temperature, rain, and poor quality. This condition will adversely affect the mobility of road users, such as traffic jams, long travel hours, and even accidents [1].

One of the efforts to enhance the quality of road pavement (asphalt) is done by adding various filling materials. A kind of filler that can be used in concrete asphalt mixture is sugarcane bagasse ash. It is one alternative to reduce industrial waste where the existence of sugar processing plants in Indonesia is quite abundant [2]. This waste of sugar cane ash is not only useful to be used as road pavement mixtures in case of its economic cost and availability, but it is also positive to reduce industrial waste through beneficial actions. The sugar cane ash contains high silica (SiO$_2$) around 68.5% that can improve the quality of the asphalt layer mixture. In this study, the sugar cane ash filler as an added ingredient was in the varying levels of 0%, 5%, 10%, and 15%, respectively.

Besides using sugarcane bagasse ash, this research also employed a substitute for fine aggregate, i.e. beach sand. The use of beach sand is an alternative of fine aggregate instead of river sand in order
to anticipate the scarcity of river sand that may occur due to the declining stock in nature so it makes the price high. In some areas, sand beach has been an alternative material to replace river sand that has almost similar physical characteristics. Moreover, in the emergency situation, like the post-disaster period for example after earthquake or tsunami, it is very difficult to find fine aggregate. This study is done to determine the extent to which the influence of the beach sand as a substitute for fine aggregate in asphalt mixture compared to the river sand. This alternative is expected to maximize the quality of the asphalt mixture.

Asphalt concrete refers to a surface layer that combines hard asphalt and gradually graded aggregates in which those are mixed, spread and pressed in certain heat and temperature. This layer is waterproof, durable as well as has structural values. Its asphalt content ranges from 4-7% to the weight of the mixture, and it can be used for light, moderate, or heavy traffic. This mixture provides a high level of rigidity with three types of asphalt concrete layer, namely Asphalt Concrete Wearing Course (AC-WC), Asphalt Concrete Binder Course (AC-BC) and Asphalt Concrete Base (AC-Base).

SN1 01-2003 explains that a concrete asphalt mixture must have good mixture characteristics [3]. These characteristics include stability, flexibility, durability, surface roughness, easiness, waterproof, and flow resistance. The stability aspect shows the ability of the paved mixture to resist plastic or permanent deformation due to the traffic loads. It can also be defined as the ability of the pavement layer to serve traffic loads without experiencing permanent deformation, such as waves and furrows. The stability can be maximized if the aggregate has a rough surface and sufficient asphalt volume.

Asphalt materials cover asphalt, coarse aggregate, fine aggregate, and filler [4]. Asphalt is a material that forms the surface layer of flexible and composite pavement [5]. Asphalt can also be used as a binding course to stabilize subgrade or foundation layers. This material is from the result of crude oil filtering and of the petroleum industry. It is a material for adhesives with the color of dark brown to black, and the main dominant element of bitumen.

Asphalt at low temperatures will become solid or semi-solid, while asphalt at high temperatures tends to soften [5]. During the maintenance of asphalt pavement, there must be enough water to cover the aggregate with asphalt. Asphalt in the pavement layer functions as a binding material among aggregate grains to form a dense material, so that it can provide mixed strength and durability to bear vehicle loads. Filler is a material that passes the filler No 200 (0.075mm diameter) [5]. The fillers must be dry and free of other harmful substances since those function as a filler between coarser aggregate particles to make the air cavity smaller and to produce high friction resistance and inter-grain locking, thereby increasing the stability of the mixture. The content of filler in asphalt concrete mixture will affect the process of mixing, spreading, and pressing. In addition, the filler influence the elasticity of the mixture and its sensitivity to water. Based on SNI 03-1737, the filler must be dry and free from other disturbing materials if the wet sieve analysis is done [6].

Testing with Marshall equipment is carried out by referring to the Bina Marga regulation [7]. The Marshall Test is to determine the characteristics of the mixture and the resistance or stability toward the flow of the asphalt mixture. The relationship between resistance (stability) and flow is directly proportional where the better the stability, the bigger the flow to be achieved, and vice versa. So, the more stability of the asphalt will be better to withstand the load and vice versa. Similarly, if the flow is higher, the asphalt will be better to withstand the load. According to the observation results on the Marshall test, it is arranged a graph on the relationship between the percentage of asphalt levels and the percentage of Void in Mineral Aggregate (VMA), Voids in the mix (VIM), flow, stability, and the ratio between stability and flow-Marshall Quotient (MQ).

VMA is the percentage between the cavity and the aggregate expressed in integers. VMA and VIM are indicators of durability. VIM shows the percentage of cavities in the mixture. The higher VIM indicates the greater the cavity in the mixture so that the mixture is porous. VIM should be 3-5% based on the Bina Marga regulation [7]. VIM consists of air space between aggregate particles coated with asphalt. Marshall Quotient states the rigidity of a mixture. If the MQ value is too high then the mixture will tend to be too stiff and easy to crack. If the MQ value is too low, the pavement becomes too flow and tends to be less stable. The indicates that the required value of the Marshall quotient (MQ) is above 250 kg/mm² [7]. MQ values in asphalt mixtures can be determined using the formula of \( M.Q = S/F \). The value of flow is indicated by the gauge needles melting watches in the Marshall device. The melting
value can be obtained from the results of reducing the initial average diameter of the test specimen before and after testing with the mean of diameter and the test specimen. Void Filled with Asphalt refers to the percent of cavities contained between aggregate particles (VMA) filled by asphalt excluding asphalt absorbed by aggregates.

2. Research Method

The study was conducted at the Road Laboratory, Department of Civil Engineering and Planning Education, Faculty of Engineering, Universitas Negeri Yogyakarta. This study employed the experimental method. The purpose of this study is to determine the effect of beach sand as fine aggregate and the sugarcane bagasse ash filler in concrete asphalt mixture on Marshall characteristics. This study used filler treatment with a percentage of 0%, 5%, 10%, and 15% in the mixture of concrete asphalt layers. This study used 3 specimens per treatment with the total of 12 specimens.

The first test is asphalt testing to determine the penetration value of asphalt, softening point, flash point, and asphalt fire point. Each asphalt test was done at least 2 times. The second test was a coarse and fine aggregate test of which this aggregate test is to determine the value of the aggregate filter analysis, specific gravity, and water absorption. The third test involved the filler test to determine the value of the specific gravity of the filler. The fourth test was to decide the optimum asphalt content (KAO) with the asphalt content of 5%, 5.5%, 6%, 6.5%, and 7%, respectively. This optimum asphalt content was used to create the test specimens. KAO used was 6.5% of asphalt. The last test was the asphalt mixture using the Marshall test to reveal the value of density, stability, flow, Void in the Mix (VIM), Void in Mineral Aggregate (VMA), Void Filled with Asphalt (VFA), Marshall Quotient (MQ).

The fine aggregate was taken from the sand of Parangtritis beach. The fillers contained sugar cane ash from Maduskismo sugar factory, Kasihan, Bantul, Yogyakarta, while the asphalt was obtained from Pertamina AC-BC Pen 60/70. The asphalt testing was based on SNI procedures including the testing on asphalt density, asphalt penetration, asphalt softening, flash point and fire point. The asphalt testing was done based on the following guidance.

| Type of Test          | Reference              | Minimum | Unit   |
|----------------------|------------------------|---------|--------|
| Penetration          | SNI 06-2456-1991       | 50      | mm     |
| Softening point      | SNI 06-2434-1991       | 53      | °C     |
| Flash point & burn   | SNI 06-2433-1991       | 232     | °C     |
| density              | SNI 06-2441-1991       | 1       | g/cc   |

| Filler (%) | Asphalt (%) | Aggregate (%) | Mould (%) |
|------------|-------------|---------------|-----------|
| 0          | 6,5         | 93,5          | 100       |
| 5          | 6,5         | 88,5          | 100       |
| 10         | 6,5         | 83,5          | 100       |
| 15         | 6,5         | 78,5          | 100       |

3. Result and Discussion

3.1. Asphalt

As mentioned above, the asphalt testing was conducted through a number of tests including the testing of penetration, softening point, flash point, fire point, and asphalt specific gravity. This test was carried out twice per trial based on SNI 06-2456 [8]. The following are the results of Asphalt test.
### Table 3. Asphalt testing result

| Type of Test | Reference | Result | Unit |
|--------------|-----------|--------|------|
| Penetration  | 50        | 64.2   | mm   |
| Softening point | 53      | 57.75  | °C   |
| Flash point  | 232       | 234    | °C   |
| Burn point   | 320       |        |      |
| Density      | 1         | 1.193  | gr/cc|

3.2. Aggregates

This test consisted of aggregate sieve analysis, the specific gravity and aggregate absorption. Aggregate testing is carried out based on SNI 06-2441 [9]. The rough aggregate test shows the results of the void value of 46.74%, while the aggregate test results are presented below.

### Table 4. Aggregate testing result

| Type of Test | Coarse Aggregate | Fine Aggregate | Unit |
|--------------|------------------|----------------|------|
| Density      | 2.5              | 2.6            | gr/cc|
| SSD          | 2.55             | 2.7            | gr/cc|
| Absorption   | 2.81             | 2.89           | gr/cc|
| Filler       | 2.55             |                | gr/cc|

3.3. Marshall Test

Marshall testing aims at getting the value of stability, flow, density, VIM, VMA, VFA, and MQ. Marshall testing was conducted by referring to SNI 06-2489 [10]. This study used Parangtritis beach sand as a substitute for fine aggregate and cane ash filler with the levels of 0%, 5%, 10%, and 15%, respectively. The test results are presented below.

### Table 5. Marshall testing result

| Sample | Mean | VIM | VMA | Flow | VFA | MQ |
|--------|------|-----|-----|------|-----|----|
| 0%     | 9.42 | 15.18 | 6.88 | 47.31 | 621.45 |
| 5%     | 7.4  | 12.68 | 2.28 | 41.69 | 1,266.76 |
| 10%    | 6.84 | 11.56 | 4.375 | 40.9 | 613.173 |
| 15%    | 6.04 | 10.2  | 3.725 | 41.47 | 1,386.74 |

The asphalt penetration testing was done twice. The average value of 64.2 grams/mm/sec. The results of this penetration test indicated that asphalt can be categorized as the asphalt type I with the penetration of 60/70 as mentioned in the Bina Marga regulation. Meanwhile, the asphalt softening point test with ring and ball method ranged from 30° to 200° C. If the asphalt softening point value is less than 30° C or more than 200° C, it means that the asphalt does not meet the standards of asphalt softening point. From the results of the asphalt softening point tests, it was obtained the average temperature of 58°C, while the flash point test indicated 234°C. Based on the results of this flash point test, it can be concluded that the flash point test has fulfilled the 2010 Bina Marga regulations, i.e. the minimum of 232°C.

The test of the fire point data showed the value of 320° C. Moreover, the results of flash point test meet the minimum requirements of 232° C. The filler test obtained bulk density results of 2.07 gr/cc, bulk density of 2.25 gr/cc, and apparent density of 2.55 gr/cc. The purposes of Marshall test are to reveal the values of stability, flow, density, VIM, VMA, VFA, and MQ. Marshall testing was conducted based on SNI 06-2489-1991 [10]. This study used the sand from Parangtritis beach as the substitute for fine...
aggregate and the sugar cane ash filler. In Figure 1 below, it showed VMA value with the sugarcane ash filler content of 0%, 5%, 10%, and 15% that resulted in 15.18%, 12.68%, 11.56%, and 10.20%, respectively. These results indicate that the higher the levels of sugar cane ash filler, the lower VMA value. The highest VMA value was found in asphalt mixture with 0% filler content and the lowest VMA value with 15% filler content. It means that the cavity space in aggregate particles with the addition of filler can be lower because of its nature as the filler and binder in the asphalt mixture. VMA value with 0% filler content has met the 2010 Bina Marga standard, i.e. the minimum requirement of 14%. Meanwhile, the mixture of 5%, 10%, and 15% content did not meet the requirements.

The Marshall Quotient (MQ) value states the stiffness of a mixture. Figure 2 below shows that MQ values with the sugarcane ash filler content of 0%, 5%, 10%, and 15% were 621.45 kg/mm, 1266.76 kg/mm, 613.173 kg/mm, and 1.386,74 kg/mm. The highest MQ value was found in the asphalt mixtures with 15% filler content, and the lowest MQ values using 10% filler content that meet the 2010 Bina Marga regulation. The factors that affect MQ values including the stability and the flow of asphalt mixture. The Bina Marga regulations [7] requires a regulation oblige the minimum MQ value of 250 kg/mm.

Picture 1. Graphic relationship of ash filler with VMA

Picture 2. Graphic relationship of ash filler with MQ
4. Conclusion
Based on the above discussion, it can be concluded that 1) the use of Parangtritis beach sand as the substitution of river sand on the mixture of concrete asphalt layers affects the characteristic value of Marshall. It is indicated by the more filler content, the lower VIM, VMA, and VFA values so that the cavity in the asphalt mixture is getting lower. The testing results present the specific gravity and the absorption of beach sand have met the 2010 Bina Marga regulations; 2) the use of sugar cane ash filler in the concrete asphalt layer mixtures with 0%, 5%, 10%, and 15% content affects the characteristic value of Marshall. The more filler content in the asphalt mixture, the bigger the stability and MQ values, while the flow value, density, VIM, VMA, and VFA are getting smaller. The other factors that influence the characteristic values of Marshall are asphalt content, aggregate gradation, pressing temperature, mixture quality, and asphalt mixing process.

5. References

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