Characteristics of Porous Asphalt Mixture by Using a Bottom Ash Boiler as a Filler

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Abstract. Porous asphalt is asphalt mixture using open gradation dominated by coarse aggregate to produce a large enough cavity. Bottom ash waste produced by a boiler used in the extraction process of palm oil into crude palm oil. Shells and pulps that has been burned at high temperature between 500°C to 700°C will later become of boiler bottom ash. The aim of this study was to inspect the performance of Porous Asphalt Mixture characteristics which combining bottom ash boiler and cement as filler using Retona Blend 55 as a binder. The specimen preparation were designed by the Australian Asphalt Pavement Association (AAPA) method by parameter of Cantabro Loss (CL), Asphalt Flow Down (AFD), Voids In Mix (VIM), Stability and Marshall Quotient (MQ). The Optimum Asphalt Contain (OAC) obtained used to prepare specimens within OAC with variation 50 % bottom ash boiler and 50 % cement as filler. The result of study showed that the OAC obtained 6%. Almost all parameter values were meet to the required specification of AAPA (2004). The value of CL is 9.25 %, AFD value is 0.19%, Stability 573.27 kg, flow 4.7 mm and VIM 12.29%. The value of VIM not meet to required specification (18%-25%).

Keywords: bottom ash boiler, porous asphalt mixture, AAPA 2004, filler

1. Introduction

Pavement is composed of various materials originating from nature. The selection of material was carried out based on various factors including the pavement structure requirements, economic, durability, ease of work and local area experience (Hardiyatmo 2019). Increased infrastructure development in Indonesia especially roads has led to scarcity and high prices of materials in the market. Innovation is needed to find alternative materials that can be used to overcome these problems.

Aceh Province is an area that has a fairly large area of oil palm plantations, oil palm today is indeed to be excellent because of its very high economic value. In the South West region of Aceh, oil palm plantations are very easy to find as are palm oil processing factories. These factories produce waste including oil palm shells and oil palm fibres. At present the utilization of palm oil waste has a variety of uses including being used as a road hardener / asphalt replacement, especially in oil palm plantations. This waste is also used as fuel for the furnace where steam is usually called a boiler. Boilers are used in the process of extracting palm fruit into crude palm oil (CPO). The results of the combustion process of palm kernel shell and palm pulp in the boiler machine produces waste, one of which is a bottom ash. Bottom ash will be accommodated at the bottom of the furnace. Bottom ash have many pores and greyish white. This boiler bottom ash is a waste that is mostly produced by crude palm oil.
An alternative solution in overcoming scarcity is to utilize bottom ash boiler boiler crust as road pavement material. Utilization of bottom ash boiler crust aims to reduce factory waste so as not to cause environmental pollution around the plant.

Flexible Pavement is a type of road pavement that is widely used in Indonesia. One type of mixture in flexible pavement is porous asphalt mixture. Porous Asphalt is a mixture of asphalt that is designed to have higher porosity than other types of pavement. According to (Diana 2004) porous asphalt is an open graded asphalt hot mixture with a large percentage of coarse aggregate, a small percentage of fine aggregate, thus providing a large air cavity. This air cavity is expected to be able to escape water when it rains, so water is not flooded on the road surface.

The ingredients of the pavement layers consist of aggregate, asphalt and filler. According to (Hardiyatmo 2019), filler material is a fine-grained material that passes through filter no. 200 (0.075 mm), can consist of rock dust, limestone, Portland cement, or other non-plastic materials. Fillers must be dry and free of other harmful substances.

(Suparma 2014) conducted a study using palm ash ashes as a filler in HRS-base mixture. The study was conducted by making variations of oil palm ash as a substitute for filler 0%, 25%, 50%, 75%, and 100%. The results of the mixed characteristics test showed that the HRS-Base mixture using an aggregate of palm fiber ash ash and oil palm shell ash has the potential to be resistant to deformation but less resistant to cracking due to tensile.

Based on the above problem conditions, it is necessary to conduct research on the use of a bottom ash boiler crust as a filler in porous asphalt mixture

2. Experimental/Methods
The entire study was conducted at the Transportation Laboratory of the Faculty of Engineering, Syiah Kuala University, Banda Aceh (Figure 1).

![Figure 1. Location of Study In Transportation Laboratory](image-url)
The study conducted a collection of data that is useful for the research process, the data needed is primary data and secondary data. Primary data were obtained from marshall test results of concrete asphalt mix specimens. While secondary data is supporting data obtained from material production brochures and other literature.

2.1 Material Preparation and Procurement

2.1.1 Aggregate

According to (Sukirman 2003), aggregate is the main ingredient of the road pavement structure, which is 90-95% aggregate based on weight percentages, or 75-85% aggregate based on volume percentages. Thus the quality of road pavement is also determined by the nature of the aggregate and the aggregate yield used by other materials. The aggregate properties that determine its quality as road pavement material are gradation, cleanliness, aggregate hardness and durability, grain shape, surface texture, porosity, ability to absorb water, specific gravity, and adhesion with asphalt. Ageragat used in this research is split aggregate derived from stone crusher Kaway Beton, Aceh Barat

2.1.2 Retona Blend 55 Aspal

Asphalt retona blend is one of the asphalt which is the production of PT. Olah Bumi Mandiri. This asphalt is asphalt which has been modified / the result of a mixture of oil asphalt pen 60 or pen 80 with asbuton refined butona asphalt which is fabricated.

2.1.3 Bottom Ash Boiler Filler

Palm kernel shells and palm pulp that have been burned at high temperature between 500°F to 700°F will deform into Palm Oil Clinker (POC) that has been widely accepted as disposal waste in the industry. After being burned under high temperature, palm kernel shell and palm pulp will deform into remnants which is considered as boiler waste and it comes in the form of: 1. Ashes (Bottom Ash and Fly Ash); accumulated under the furnace, collected into ashes collecting point and is relatively heavyweight; 2. Clinker; boiler clinkeris derived from palm kernel shell and attached to the boiler wall. Bottom ash will be accommodated at the bottom of the furnace. Bottom ash have many pores and greyish white. Bottom ash filtered to pass filter no. 200 in accordance with the specifications required. The bottom ash used in the study came from a palm oil processing factory operating in Padang Sikabu, Aceh Barat

![Figure 2. Bottom Ash Boiler](image)

2.2 Test Specimen

The test specimen is made up of 2 (two) groups, namely:

Asphalt concrete wearing course (AC-WC) specimens with asphalt retona blend 55 for determining optimum asphalt contain.

After OAC is obtained, then the specimens are made on OAC asphalt mixture with a variation of 50% bottom ash boiler and 50% cement use a mixture of asphalt pourus based on that quoted from the (Anonim 2004).
2.3 Selection of aggregate gradations
Gradation used in this study is gradation of asphalt porous mixture (open gradation) based on what was quoted from the (Anonim 2004), using a maximum aggregate size of 14 mm as shown in table 1.

| Sieve size | Aggregate | % weight pass | Aggregate |
|------------|-----------|---------------|-----------|
| 19.0       | 100       | 100           |           |
| 13.2       | 100       | 85-100        |           |
| 9.5        | 85-100    | 45-70         |           |
| 4.75       | 20-45     | 10-25         |           |
| 2.36       | 10-20     | 7-15          |           |
| 1.18       | 6-14      | 6-12          |           |
| 0.6        | 5-10      | 5-10          |           |
| 0.3        | 4-8       | 4-8           |           |
| 0.15       | 3-7       | 3-7           |           |
| 0.075      | 2-5       | 2-5           |           |
| Total      | 100       | 100           |           |
| Asphalt content | 5,0-6,5 | 4,5-6,0 | |

2.4 Specimens to find the optimum asphalt content (OAC)
Tested specimens were created from Asphalt Concrete - Wearing Course (AC-WC) mixture used BinaMarga 2010 Spesification. Its contains bottom ash boiler as filler. Marshall Evaluation was carried out on the specimens to investigate their Optimum Asphalt Content (OAC). The characteristics of asphalt concrete mix can be checked using Marshall Test. This check is intended to determine the resistance (stability) to the plastic discharge (flow) of the asphalt mixture.

The test specimen is made using filler variations in accordance with the mix design plan contained. The specimen is made into variations with addition bottom ash filler 50% and cement filler 50% (15 specimen). The design of the number of test specimens Table 2.

| OAC | Asphalt Content |
|-----|-----------------|
| Pb 1% | Pb 0.5% | Pb | Pb+0.5% | Pb+1% |
| 3    | 3       | 3  | 3       | 3      | 15    |

2.5 Specimens on the optimum asphalt content (OAC)
After obtaining OAC, then the test specimens are made on the OAC. The specimens used AAPA (Australian Asphalt pavement Association) 2004.

| No | Kriteria Perencanaan | 2004 |
|----|----------------------|------|
| 1  | cantabro loss(CL)(%)  | < 35 |
| 2  | Asphalt flow down (AFD)(%) | < 0.3 |
| 3  | Marshall Stability (kg) | ≥ 500 |
| 4  | Flow (mm)             | 2-6  |
| 5  | Voids in Mix (%)      | 18-25|
| 6  | number of collisions per field | 50   |

Source: AAPA, 2004
The total specimens are 9 specimens for Marshall testing. Furthermore, the specimens were made again for CL and AFD testing of (6) (three) test specimens so that the number of test specimens became 18 pieces. The design of the number of test specimens Table 4.

**Table 4.** The number on Optimum Asphalt Content (OAC) specimens

| Method         | Number of Specimen |
|----------------|--------------------|
|                | 30 minutes waterbath | 24 hours waterbath |
| Marshall       | 3                  | 3                |
| Cantabro Loss  | 3                  | 3                |
| Asphalt Flow Down | 3             | 3                |
| Total          | 9                  | 9                |

**3. Result and discussion**

The results of this study presented are the results of evaluating the use of bottom ash boiler as a filler for the characteristics of asphalt porous mixtures.

*Marshall Evaluation in the Mixture of AC WC with Retona Blend 55 variation using bottom ash and cement as filler to investigate Optimum Asphalt Content (OAC).*

Table 5 shows that specimens of AC WC mixture with varied content of Retona Blend 55 (4.5; 5; 5.5; 6; 6.5); these specimens did contain bottom ash and cement as filler. Marshall Evaluation was carried out on the specimens to investigate their OAC.

**Table 5.** Recapitulation of Marshall test in the Mixture of AC WC with Retona blend 55 content variation using 50/50% bottom ash boiler and cement as filler

| No | Mixture Characteristic | Asphalt Content (%) | Dept Specification |
|----|------------------------|---------------------|--------------------|
|    |                        | 4.5 5 5.5 6 6.5     |                    |
| 1. | Stability (kg)         | 823.253 866.92 595.35 742.16 841.39 | > 800 kg           |
| 2. | Flow Plastic (mm)      | 2.77 2.9 3 2.50 2.80 | min 3 mm          |
| 3. | MQ (Kg)                | 297.20 301.79 201.27 296.87 300.5 | > 250             |
| 4. | VIM (%)                | 6.87 8.4 7.35 2.26 4.56 | 3.5-5.5 %         |
| 5. | VMA (%)                | 16.73 19.1 19.17 15.76 18.75 | > 15 %            |
| 6. | VFB (%)                | 58.96 63.41 61.66 85.71 75.67 | > 65 %            |

*Marshall Evaluation in the Mixture of Pourus Asphalt with Retona Blend 55 Asphalt on OAC using Bottom Ash Filler and cement as filler*

Table 6 shows that specimens of Pourus Asphalt mixture with variation 50:50% on 6% OAC; these specimens did contain bottom ash and cement as filler.

**Table 6.** Recapitulation of Marshall test in the Mixture of Pourus Asphalt with Retona blend 55 content variation using 50/50 % bottom ash boiler and cement as filler

| No | Mixture Characteristic | Asphalt Content | AAPA 2004 Specification |
|----|------------------------|-----------------|-------------------------|
| 6.0|                        | 6.0             |                        |
30 minutes | 24 hours
---|---
1. Stability (kg) | 573,27 | 504,58 | Min. 500
2. Flow (mm) | 4,7 | 4,8 | 2 - 6
3. MQ (Kg) | 121,97 | 105,12 | Max. 400
4. VIM (%) | 12,29 | 10,93 | 18 - 25
5. Cantabro Loss (%) | 9,25 | | Maks. 20
6. Asphalt Flow Down | 0,19 | | Maks. 0,3

Cantabro loss testing at 6% asphalt content meets specifications that are <20%, this shows that the mixture’s resistance to aggregate release is good, because the release of grains that occur after being removed from a Los Angeles machine is smaller than the required specifications.

Asphalt flow down (AFD) testing at 6% asphalt content meets specifications that is <0,3%, so it can be concluded that the mixture of asphalt and aggregate is good because the asphalt content can be mixed homogeneously so that asphalt separation does not occur.

Marshall Test, the stability of 30 minutes immersion and 24 hours immersion of 50%: 50% filler composition is above the required specifications of minimum 500 kg. At the 30 minute immersion the stability value is 573,27 kg and at the 24 hour immersion the stability value is 504,58 kg, this is because the longer the immersion the smaller the stability value that can and the filler is not able to mix well with asphalt so that the pavement becomes flexible and less stable.

The flow value produced in the 30 minute immersion is 4,7 mm and the 24 hour immersion is 4,8 mm. This shows that the flow value decreases but is still above the specifications, in the field the high flow value has an unfavorable impact, because when the traffic is passed heavy and slow resulting in changes in the shape of the asphalt.

The VIM value generated at 30 minutes immersion is 12,29% and at 24 hours immersion is 10,93. If the VIM is too small, the asphalt mixture will be impermeable to water.

The Marshall Quotient value produced at 30 minutes immersion is 127,97 kg and at 24 hours immersion is 105,12 kg this shows that the higher the level of retana, resulting in a lower Marshall Quotient. The increase and decrease in the value of MQ is influenced by the stability and flow of the mixture.

4. Conclusions

Marshall Evaluation was carried out on the specimens to investigate their Optimum Asphalt Content (OAC). We got 6% OAC for variation of filler 50% bottom ash boiler and 50% cement.

The stability value obtained meets the specifications required by AAPA 2004 with the value 573, 27 > Min. 500 kg.

Asphalt Flow Down (0,19<03) and cantabro loss (9,25<20) values meet the requirements.

VIM values (12,29) was not acquiescent to the required specification.

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