The effect of using asbuton with used waste diesel oil on the stability of the porous asphalt mix with hot mix cold laid method.

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Abstract. The abundant availability of Asbuton in Indonesia should be proportional to the percentage of its use, however, in the implementation of pavement works, it is still dominated by petroleum asphalt, the price of which tends to be higher than the Asbuton. If you look at the elements in Asbuton, namely minerals and bitumen, it should be superior to petroleum asphalt. One of the factors where the use of Asbuton is not optimal is that the stability value of the mixture using Asbuton is still low compared to the mixture using petroleum asphalt. So this research aims to analyze the stability value of the porous asphalt mixture using Asbuton and waste oil as a rejuvenating agent with hot mix cold laid method. The research method was carried out by carrying out test objects with variations in Asbuton content of 5%, 5.5% and 6% with variations in fuel wastage rate of 0%, 2%, 3% and 4%. The total number of test objects is 36 samples. Then the Marshall test was tested to determine its stability value. The results obtained based on the test results are the highest average stability value at the variation of the levels of Asbuton 6%, 5.5% and 5% respectively 1295.3 Kg with 4% waste oil content; 1238 Kg with 3% used oil; and 773 kg with a waste oil content of 2%. Adding the Asbuton content increases the stability value; however, the level of used oil in the best results still varies. It can therefore be concluded that the highest stability value of a hollow asphalt mixture using an Asbuton content of 6% and a waste oil content of 4% with a value of 1295.3 Kg, meets the specification of the Road Engineering Association of Malaysia (REAM).

1. Introduction
The increase in traffic activity must be accompanied by an increase in inadequate transport infrastructure, in particular roads. Building good infrastructure to facilitate access to transport obviously requires much funding. One solution that has been taken is the rehabilitation of roads by adding a layer of pavement. However, this solution remains a problem as it will cause high road elevation and increase the use of new materials. While another alternative is needed to achieve the development of road infrastructure at a low cost. The recycling method can be adopted as a new innovation considered effective and efficient in the road construction world.
The use of waste as recycled material should always refer to the PP. 18 of 1999 concerning the management of hazardous and toxic waste (B3) called for the dangers of hazardous and toxic waste to the environment. One of the B3 wastes is used oil, which so far is still little used and widely available. Research results indicate that used oil is a type of heavy oil that can be used as a modifier [1]. The trend towards the use of modifiers in asphalt mixes continued until 1987; for conventional grain asphalt mixes like Lasbutag and Lataasum, rejuvenating agents are used, including fuel oil or Flux Oil [2]. Use of a modifier to soften and rejuvenate the properties of asphalt. However, this is very difficult to achieve, where the bunker oil cannot release the bitumen and then keep it soft; it takes 254 days for the fuel oil regenerator to reach the granular Asbuton bitumen, and hence the mixture. It is not maximum paved [3]. This condition was also recommended by [4] to use a modifier other than flux oil due to its rarity.

Another thing that makes the use of Asbuton less than optimal is that many studies and studies have shown that the bitumen in Asbuton grains is difficult to separate from minerals, so it does not have been wrapped to the maximum and becomes a good binder between aggregates [5] as we know that the availability of Asbuton is abundant in Indonesia and that its use is not optimal compared to the use of petroleum asphalt. Other countries like Trinidad, France, and Italy have, in fact, applied natural asphalt in road construction [6]. One of the advantages of an asphalt mix using petroleum asphalt is the excellent performance of the mix as the oiled asphalt is able to improve the adhesion of the mix and facilitate mixing and compaction [7].

The state of Indonesia, with its rainy season, creates problems, especially the construction of roads. Stagnant water on the road surface is the start of road damage. It, therefore, needs innovation to manage these conditions. One of them is the construction of roads that have pores to function as drainage or commonly known as porous asphalt. Most porous asphalt gradients use coarse aggregate, so the resulting asphalt mixture tends to be hollow. Besides petroleum asphalt, which can be used as a binder, it turns out that Buton asphalt can also be used in this way with the addition of a modifier. The abundance of used oils that can be used on road pavements with a recycling process. This is because asphalt that has a high viscosity requires solvents with lower viscosity levels so that the rejuvenating agent can spread evenly over the recycled asphalt aggregate.

Previous studies have shown that the more Asbuton and less rejuvenating agent are mixed, the higher the resulting stability value [8]. It is therefore considered necessary to conduct research on the effect of using Asbuton with used diesel oil on the stability of the porous asphalt mix with the hot and cold asphalt method using various variations. Of used oil level and Asbuton levels so that a mixture design with high stability values.

2. Methodology

The method used in this study is an experimental laboratory method. The search variable here is the type of used oil in several porous asphalt mixes. The test to determine the stability value of the Porus Asphalt blend is the characteristics of the Marshall test using the Marshall test tool. The standard or specification used is the specifications of the Association of Road Engineering of Malaysia (REAM). The materials, equipment, mixture, and experimental designs are described as follows:

2.1 Material and equipment

The materials used in this study were Asbuton type LGA 50/30, 60/70 penetration oil asphalt, coarse aggregate / crushed stone (maximum size 20 mm), fine aggregate / local sand (size maximum 4.75), and used diesel engine oil. The equipment used in this research is an oven, sieve, marshal tools, pans, scales, moles with a capacity of 1200 grams, and other supporting equipment.

2.2 Aggregate manufacturing process
Used oil and LGA 50/30 are mixed and cured for 24 hours before being mixed with other materials, and then after curing, they are mixed with aggregates which have been previously heated to $\pm 165^\circ C$ and 1 oil asphalt, after being mixed and compacted at a cool temperature of $\pm 50^\circ C$. The complete process of manufacturing the test specimen for Porous Asphalt Mixture using waste oil waste is shown in Figure 1.

### Figure 1. Manufacturing flow of a porous asphalt mix

#### 2.3 Mixed Design and Research Procedures

The process of making a porous asphalt mix, before the aggregate characterization inspection, is carried out before the design mix calculation based on the specifications of the Association of Road Engineers of Malaysia (REAM). The specimens were made with a variation of diesel engine oil wastage respectively 0%, 2%, 3%, 4% variation of Lga 5%, 5.5%, 6% of the total mixture. Each sample consisted of 3 mixed variations using one mole with a capacity of 1200 grams.

### Figure 2. Research Flow
From the data of the design of the mixture, continue to mix using a pan and stove. Before doing the mixing process, the used oil and Lga are mixed and hardened for 24 hours; the mixture first heating the aggregate, heated to ± 165°C, then mix it with the waste oil and Lga. After being evenly mixed, the petroleum asphalt which has been preheated is also mixed until the entire surface of the aggregate is covered. After that, the mixture is matured until it reaches a temperature of 50°C and compacted. Before the mixing process, first of all, an examination of the constituent material of the porous asphalt mixture is carried out. After 24 hours, the test object was made, then the testing process was performed for every three samples for every variation.

3. Results and discussion
To determine the physical properties of aggregates, a test is carried out in the laboratory to obtain characteristic values that meet specifications. The results of the examination of the physical properties of the aggregates will be presented below.

3.1 Physical properties of coarse aggregates
Coarse aggregate physical property test results were carried out according to the Indonesian National Standard (SNI) test method.

| No. | Testing          | Interval Value | Result |
|-----|------------------|----------------|--------|
| 1   | Absorption (%)   | Max. 3         | 1.58   |
| 2   | Specific Gravity (%) |              |        |
| a. | Bulk Specific Gravity | Max. 3        | 2.58   |
| b. | SSD Specific Gravity | Max. 3        | 2.62   |
| c. | Apparent Density | Max. 3         | 2.69   |
| 3   | Porosity (%)     | Max. 40        | 31.6   |
| 4   | Flakiness Index  | Max. 25        | 24.8   |

Table 1 shows that the inspection value of coarse aggregates with broken stones meets the general specifications of Direktorat Jenderal Bina Marga Kementerian Pekerjaan Umum, 2010 (Revisi 2).

3.2 Physical properties of fine aggregates
The results of the physical property testing of fine aggregates carried out according to the Indonesian National Standard (SNI) test method are shown in Table 2.

| No. | Testing          | Interval Value | Result |
|-----|------------------|----------------|--------|
| 1   | Absorption (%)   | Max. 3         | 2.46   |
| 2   | Specific Gravity (%) |              |        |
| a. | Bulk Specific Gravity | Max. 3        | 2.70   |
| b. | SSD Specific Gravity | Max. 3        | 2.76   |
| c. | Apparent Density | Max. 3         | 2.89   |
| 3   | Sludgy Levels (%)| Max. 5         | 4.73   |

Table 2 shows that the fine aggregated control value meets the general specifications of the Direktorat Jenderal Bina Marga Kementerian Pekerjaan Umum, 2010 (Revisi 2).

3.3 Determination of mixed gradation
Determination of the combined particle size according to the specifications of the Association of Road Engineers of Malaysia (REAM).
Table 3. Combined Analysis

| Sieve Number | No. 1.5 | No. 1 | % PASS  | % BATCH |
|--------------|--------|------|---------|---------|
| Crushed Stone 85 | 100 | 100 | 88.07 | 74.86 |
| Sand 15 | 100 | 100 | 100 | 100 |
| Combined Aggregate Specification | 100 | 90-100 | 73-90 | 55-76 | 45-66 | 28-39.5 | 19-26.8 | 12-18.1 | 7-13.6 | 5-11.4 | 4.5-9 | 3-7 |

Figure 3. Aggregate Mix Gradation

Table 3 and Figure 3 show that the combined aggregate grading test results meet the specifications of the Association of Road Engineering of Malaysia (REAM).

3.4 Asphalt mix test

Marshall test

The Marshall test aims to measure the durability (stability) of the mixture of aggregates, asphalt against molten plastic (flow), and the Marshall quotient, which is the development value of stiffness (pseudo-stiffness). Another important parameter is the analysis of voids consisting of Void In the Mix (VIM), Void in material aggregate (VMA), void filled with asphalt (VFA). Can be seen in Table 4. Marshall Test Results REAM Specifications.

Table 4. Marshall Parameter Value with 6% LGA Level

| Waste Oil Sample | LGA | VIM | VMA | VFB | Stability | FLOW | MQ |
|------------------|-----|-----|-----|-----|----------|------|----|
| Percent | No | % | % | % | Kg | Mm | Kg/mm |
| 0% | 1 | 2.00 | 15.20 | 86.83 | 1309.62 | 4.70 | 211.77 |
| 2 | 2.87 | 15.95 | 82.00 | 1180.81 | 3.80 | 236.16 |
| 3 | 3.98 | 16.91 | 76.46 | 880.24 | 4.50 | 148.66 |
| Average | 2.95 | 16.2 | 81.76 | 1124 | 4.33 | 198.86 |
| 2% | 1 | 2.95 | 16.02 | 81.76 | 1124 | 4.33 | 198.86 |
| 2 | 6.54 | 19.12 | 65.81 | 859 | 4.10 | 159.19 |
| 3 | 2.16 | 15.34 | 85.90 | 1181 | 4.11 | 218.35 |
| Average | 3.82 | 16.77 | 78.10 | 1138 | 3.89 | 226.74 |
| Percent | No | LGA | VIM | VMA | VFB | Stability | FLOW | MQ |
|---------|----|-----|-----|-----|-----|-----------|------|----|
| 0%      |    |     | 10.19 | 21.35 | 52.28 | 815.83 | 3.70 | 167.58 |
|         |    |     | 9.78 | 20.99 | 53.41 | 515.26 | 2.00 | 195.80 |
|         |    |     | 11.64 | 22.62 | 48.54 | 708.48 | 4.70 | 114.56 |
| Average |    |     | 10.54 | 21.65 | 51.41 | 680.00 | 3.47 | 159.31 |
| 2%      |    |     | 10.54 | 21.65 | 51.41 | 680.00 | 3.47 | 159.31 |
|         |    |     | 9.79 | 21.00 | 53.37 | 730.00 | 6.40 | 86.68 |
|         |    |     | 8.65 | 20.00 | 56.77 | 687.00 | 5.00 | 104.43 |
| Average |    |     | 8.88 | 20.20 | 56.11 | 773.00 | 5.07 | 123.82 |
| 3%      |    |     | 8.19 | 19.60 | 58.21 | 902.00 | 3.80 | 180.34 |
|         |    |     | 8.88 | 20.20 | 56.11 | 773.00 | 5.07 | 123.82 |
|         |    |     | 12.23 | 23.13 | 47.15 | 515.00 | 3.00 | 130.53 |
| Average |    |     | 8.15 | 19.56 | 59.46 | 508.00 | 3.50 | 118.80 |
| 4%      |    |     | 6.09 | 17.76 | 65.72 | 537.00 | 2.70 | 151.08 |
|         |    |     | 6.14 | 17.80 | 65.52 | 472.00 | 4.80 | 74.78 |
|         |    |     | 8.15 | 19.56 | 59.46 | 508.00 | 3.50 | 118.80 |
| Average |    |     | 3.40 | 15.40 | 78.69 | 522.42 | 4.27 | 96.07 |

Table 6. Marshall Parameter Value with 5,5% LGA Level

| Percent | No | LGA | VIM | VMA | VFB | Stability | FLOW | MQ |
|---------|----|-----|-----|-----|-----|-----------|------|----|
| 0%      |    |     | 6.58 | 17.20 | 61.76 | 708.48 | 3.98 | 135.29 |
|         |    |     | 5.71 | 16.43 | 65.24 | 923.18 | 4.55 | 154.20 |
|         |    |     | 10.29 | 20.49 | 49.79 | 751.42 | 4.50 | 126.91 |
| Average |    |     | 7.53 | 18.04 | 58.93 | 794.00 | 4.34 | 138.80 |
| 2%      |    |     | 7.53 | 18.04 | 58.93 | 794.00 | 4.34 | 138.80 |
|         |    |     | 11.74 | 21.78 | 46.08 | 794.00 | 4.78 | 126.30 |
|         |    |     | 10.54 | 20.71 | 49.12 | 880.00 | 4.70 | 142.34 |
| Average |    |     | 12.15 | 22.14 | 45.33 | 802.00 | 4.83 | 126.38 |
| 3%      |    |     | 14.17 | 23.93 | 40.78 | 730.00 | 5.02 | 110.51 |
|   | Stability Value | 2 | 12,15 | 22,14 | 45,33 | 802 | 4,83 | 126,38 |
|---|----------------|---|--------|--------|--------|-----|------|--------|
| 3 | Stability Value | 11,31 | 21,40 | 47,13 | 1073 | 4,11 | 198,50 |        |
| **Average** | 10,16 | 20,38 | 50,28 | 1238 | 4,30 | 219,18 |        |

|   | Stability Value | 1 | 10,41 | 20,60 | 49,46 | 1503 | 4,28 | 266,86 |
|---|----------------|---|--------|--------|--------|------|------|--------|
| 2 | Stability Value | 8,75 | 19,13 | 54,24 | 1138 | 4,50 | 192,17 |        |
| **Average** | 14,33 | 24,08 | 40,53 | 608,30 | 3,90 | 118,94 |        |

4. Conclusion
The results obtained on the basis of the test results are the highest average stability value at the variation of the levels of Asbuton 6%, 5.5%, and 5% respectively 1295.3 Kg with 4% content waste oil; 1238 Kg with 3% used oil; and 773 kg with a waste oil content of 2%. Adding Asbuton content increases the stability value; however, the level of used oil in the best results still varies. It can therefore be concluded that the highest stability value of a hollow asphalt mixture using an Asbuton content of 6% and a waste oil content of 4% with a value of 1295.3 kg meets the specification of the Road Engineering Association of Malaysia (REAM).

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