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# MARSHALL CHARACTERISTICS OF AC-WC MIXTURE WITH THE ADDITION OF ANTI-FLAKING ADDITIVES

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**ABSTRACT**

The use of additive Wetfix-Be additives in concrete asphalt mixture is an effort to improve the quality of the asphalt pavement. The aim of this study was to analyze the effect of the use of the additive Wetfix-Be additive to the performance of asphalt concrete wearing course mixture (AC-WC). This research uses asphalt penetration 60/70 with variations in asphalt content of 4.5%, 5.0%, 5.5%, 6.0% and 6.5%. Gradations are used based on the specifications required by the Department of Public Works of the Director General of Highways, so that the composition of aggregates for the mixture is obtained: coarse aggregate 37.26%, fine aggregate 18.89% and filler 6.37%. The test was carried out using the standard Marshall and Marshall Immersion methods. The results showed that the optimum bitumen content was 5.5% with Marshall Stability values of 1579 kg (> 800 kg), VIM 4.82% (3% -5%) VMA 15.29% (> 15%), VFB 68.48 % (> 65%), Flow 4.23 mm (2-4 mm), MQ 381 kg/mm (> 250 kg/mm) and Immersion Index (IP) 94% (> 90%).

**Keywords:** additive wetfix-Be, AC-WC, marshall characteristics, marshall immersion.

## 1. INTRODUCTION

The increase in number of vehicle increases the emmission quantity and creates a negative impact on the environmental surround the road infrastructure (B. Bustan *et al.*, 2016). The contractor as a service provider influences the quality of road construction and has a potential risk of the construction failure in every stage of the project. The contractor failure is always generated from the unskill workers (Sumarni Hamid Aly and Muhammad Isran Ramli, 2016). It is important to use a material that can withstand the negative impact of the vehicle emission, climate, and weather action and can be easily used in the road contruction.

The climate in Indonesia in general has high rainfall and humidity so that the aggregate must be wet. This causes many roads made in Indonesia to be damaged before the planned age, this causes more than forty percent (+ 40%) of road damage caused by water, other than an inadequate mixture of materials or an inappropriate proportion of comparison. The quality of the material used is also one of the causes of damage to the asphalt pavement before the planned age, therefore to reach the age according to plan, efforts are made to use additive additives, namely: Anti-Stripping to reduce peeling, cracking, and stiffness (brittle) on the body of the asphalt pavement.

The chemical structure of Fatty Amido-Polyamine's anti-stripping additive consists of hydrocarbon and amine ($NH_2$) chemical groups, which have similarities with the chemical elements present in asphalt. The hydrocarbon chemical group is hydrophobic and the amine group is hydrophilic. Antistripping additives are expected to add a layer of asphalt film that will cover the aggregate so as to increase resistance to peeling.

The general specification of hot asphalt mixture, Section 6.3, 2010, from the Director General of Highways of the Department of Public Works Indonesia has required the use of anti-flaking/anti-stripping additives in asphalt mixtures.

Marshall Test is an empirical laboratory test that widely used to measure of resistance to deformation (Stephen B., 2015). As the wheel passes, tensile stress arises in the pavement structure under an approaching wheel load. The tensile strength is conventionally used in pavement engineering practice as one of the key parameters in the prediction or estimation of the mechanical behavior of pavement structures (Stephen B., 2015). M.R. Islam, *et al* (M.D. Rashadul Islam *et al.*, 2015) carried out indirect tensile strength (ITS) test to evaluate the influence short-term laboratory aging (on loose mixture), long-term laboratory oven aging and field aging on the tensile strength of asphalt concrete. S. Du, 2014 carried out ITS test to evaluate the cement influence on the tensile strength of asphalt emulsion mixture

To determine the effect of anti-stripping additives in asphalt mixtures carried out experimentally testing. To observe and determine the effect of additives, the percentage of asphalt content in the mixture is used as a variable in this study.

The aims of this study to analyze the effect of adding Wetfix-Be additives to concrete asphalt mixtures (AC-WC) and to analyze the performance improvement of concrete asphalt mixes (AC-WC) by adding Wetfix-Be additives as additives.

## 2. MATERIAL AND METHOD

### 2.1 Experimental Program Test

The experimental program test has been carried outin two steps. In the first step,Marshall stabilty of the mixtures without additive Wetfix-Bewas characterized to determine the optimum content of asphalt penetration 60/70 in the AC-WC mixture.Petroleum bitument contentvaried from 4.5 to 6.5% with an increment of 0.5%. Then in the second step, at an optimum asphaltcontent,

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petroleum bitumen in penetration 60/70 was used anti flaking additive of Wetfix-Be. Marshall testswith stability, flow Marshall quetiont, VIM, VMA and VFBwere carried out to study the performance of AC-WC mixture containing anti-flaking additive of Wetfix-Be.

### 2.2 Physical Properties of Aggregate

Two fractions of coarse aggregates derived from crushed river stone were used: one with aggregate diameter 5-10 mm and the other with crushed stone diameter 10-20 mm. River sand and stone dust obtained from stone crushed process were used as fine aggregate and filler, respectively. The aggregates used for material component in cold mixture were collected from Jeneberangriver in Gowa. In this study, filler is defined as material passing a 0.075-lm sieve. The properties of coarse aggregates, fine aggregate and filler are shown in Table-1, Table-2 and Table-3, respectively.

**Table-1.** Physical properties of coarse aggregates.

| Properties | Crushed Stone | |
|---|---|---|
| | 0.5-1 cm | 1-2 cm |
| Water absorption, % | 2.07 | 2.08 |
| Bulk specific gravity | 2.62 | 2.63 |
| Saturated surface dry specific gravity | 2.68 | 2.68 |
| Apparent specific gravity | 2.77 | 2.78 |
| Flakiness index, % | 20.10 | 9.38 |
| Abrasion aggregate, % | 25.72 | 24.36 |

**Table-2.** Physical properties of stone dust.

| Water absorption, % | 2.79 |
|---|---|
| Sand equivalent, % | 89.66 |
| Bulk specific gravity | 2.45 |
| Saturated surface dry specific gravity | 2.51 |
| Apparent specific gravity | 2.63 |

**Table-3.** Physical properties of filler.

| Water absorption, % | 2.28 |
|---|---|
| Sand equivalent, % | 69.57 |
| Bulk specific gravity | 2.56 |
| Saturated surface dry specific gravity | 2.66 |
| Apparent specific gravity | 2.76 |

### 2.3 Combined Aggregates

Aggregate used is 1-2 cm crushed stones and 0.5-1 cm the aggregate gradation of mixtures was selected as the mid-point of the control limits used in the design of dense graded cold asphalt mixtures.The design limits and gradation used in this study are provided in Figure-1. The combined aggregate gradation was kept for all mixture without anti flaking additive and with anti-flaking additive. All mixtures were prepared in the laboratory. Table-4 shows the proportion of asphalt in the mixture.

Mixture without anti flaking additive and mixture with anti-flaking additive were blended and compacted into the cylindrical mold with capacity of 1, 200 gram and diameter of 101.6 mm. All specimens were compacted using the Marshall method of compaction at compactive effort of 75 blows per side. Mixing and compaction process were carried out in the laboratory at temperature room 27°C. After compaction, samples were subjected to the following curing regime prior to conducting Marshal stability: 24 h ambient laboratory conditions in the sample mold, 24 h in a soaked draft water at temperature room after demolding to obtain volumetric parameters (VIM, VMA and VFB), and cooling at laboratory conditions. Anti-flaking additive is used at optimum asphalt content as much as 2% of the weight of asphalt.

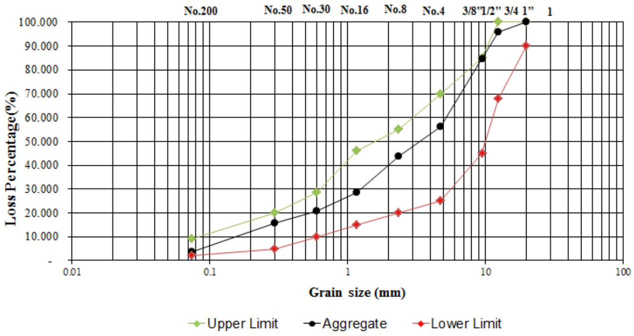


**Figure-1.** Combined aggregates gradation.

**Table-4.** Proportion of asphalt in the mixture.

| Asphalt content (%) | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 |
|---|---|---|---|---|---|
| Weight of asphalt (gr) | 54 | 60 | 66 | 72 | 78 |

### 2.4 Marshall Characteristics Test

The Marshall Stability test was conducted on AC-WC mixture specimens according to SNI 06-2489-1991. Figure-2 show the Marshall Stability test equipment. The Marshall volumetric test was conducted on AC-BC mixture specimens according to SNI 06-2489-1991. Figure-3 show the volumetric properties of asphalt mixture.

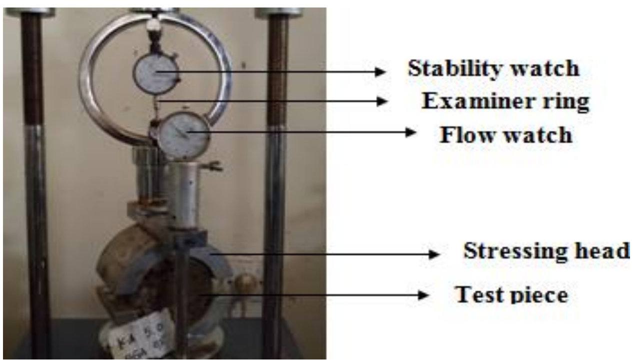


**Figure-2.** Marshall stability test equipment.

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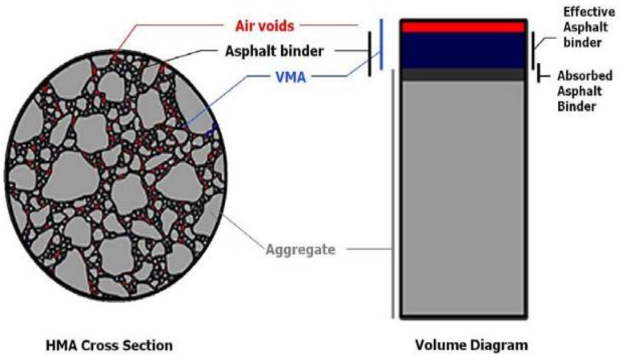


**Figure-3.** Volumetric properties.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Marshall Characteristics of AC-WC Mixture without Anti-Flaking Additive

The results of Marshall characteristic testing performed on 3 samples of specimens at 4.5%, 5%, 5.5%, 6%, and 6.5% asphalt contents obtained the average results of, Stability, Flow, MQ, VIM, VMA and VFB, as shown in Table-5. Based on the characteristics of Marshall, it can be seen that the optimum asphalt content obtained was 5.5%.

### 3.2 Marshall Characteristics of AC-WC Mixture with Anti-Flaking Additive

Marshall characteristic test results for normal test specimens obtained 5.5% optimum asphalt. These optimum asphalt levels (KAO) are compared with an additional 0.2% of additives and Marshall Characteristics are obtained as follows in Table-6.

**Table-5.** Marshall Characteristics of AC-WC mixture without anti-flaking additive.

| Asphalt content (%) | Stability (kg) | Flow (mm) | MQ (kg/mm) | VIM (%) | VMA (%) | VFB (%) |
|---|---|---|---|---|---|---|
| 4.5 | 1260 | 2.5 | 57.1 | 6.22 | 14.41 | 57.10 |
| 5 | 1441 | 2.8 | 65.0 | 5.00 | 15.00 | 65.00 |
| 5.5 | 1579 | 3.2 | 68.87 | 4.73 | 15.20 | 68.870 |
| 6 | 1437 | 3.5 | 73.975 | 4.09 | 15.70 | 73.97 |
| 6.5 | 1167 | 4.1 | 79.375 | 3.32 | 16.10 | 79.37 |

**Table-6.** Marshall Characteristics of AC-WC mixture with 0.2% anti-flaking additive.

| Asphalt content (%) | Stability (kg) | Flow (mm) | MQ (kg/mm) | VIM (%) | VMA (%) | VFB (%) |
|---|---|---|---|---|---|---|
| 5.5 without anti-flaking additive | 1579 | 4.23 | 381 | 4.82 | 15.29 | 68.48 |
| 5.5 + 0.2 % anti-flaking additive | 1886 | 3.00 | 651 | 4.73 | 15.20 | 68.91 |

Stability is the ability/strength of a mixture to accept or hold a load/pressure of traffic without changes in shape such as waves, grooves and bleeding (asphalt collection on the pavement surface) expressed in units of weight (kilograms). From the test results in the laboratory, the stability value is obtained. From the test results in the laboratory, it is obtained that the comparative value of Sabability which does not use additives 1579 kg and those using additives 1886 kg. From these results it can be concluded below by adding the Marshall Stability additive increased by 19.44% so that the asphalt mixture will be more resistant to heavy traffic loads.

Flow is the amount of plastic change in an asphalt mixture specimen that occurs as a result of a load to the limit of collapse, expressed in units of length (mm). From the test results in the laboratory, it is obtained that the Flow comparison value does not use additives 3.2 mm and those using additives 3 mm. From these results it can be concluded that by adding Flow additives decreased by 6.67% so that the performance of the mixture is increasing.

MQ is the quotient value between stability and flow; it is also a value to show the resistance of the mixture to loading every mm of the mixture. From the results of testing in the laboratory obtained a comparison value of MQ which does not use additives 506 kg/mm and those using additives 651 kg/mm. From these results it can be concluded below by adding an additive of 0.2% the Marshall quotient increased by 28.66% so that the mixed performance improved.

From the test results in the laboratory, it was obtained that the comparison value of VIM that did not use additives was 4.82% and those that used additives were 4.73%. From these results it can be concluded that by adding an additive of 0.2% cavity in the asphalt mixture

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can decrease by 1.87% so that the performance of the asphalt mixture will be better.

VMA is the volume of the cavity contained between the aggregate grains of a solid asphalt mixture, i.e. the air cavity and the volume of effective asphalt content (void in mineral aggregate), expressed in% of the total volume of the test specimen. From the test results in the laboratory, it was obtained that the comparison value of VMA that did not use additives was 15.29% and those that used additives were 15.20%. From these results it can be concluded below by adding additives 0.2% VMA results decreased by 0.59% so that the performance of the mixture is increasing because the cavities between the aggregate minerals are reduced.

Asphalt filled bitumen (VFB) is the percent of cavity contained between aggregate particles filled by asphalt, not including asphalt absorbed by aggregate. Thus, asphalt filling VFB is asphalt which functions to cover aggregate grains in the pores of solid asphalt concrete.

From the test results in the laboratory, it was found that the VFB comparison value did not use additives 68.48% and those using additives 68.91%. From these results it can be concluded that by adding cavity-filled asphalt additives in the asphalt mixture can increase by 0.63%.

### 3.3 Analysis of Marshall Immersion without and with Anti-Flaking Index

Marshall Immersion is one of the tests to see the durability (resistance to load and influence of temperature) or the durability of a mixture, the result of this test is the stability ratio. The ratio is compared to the stability of the Marshall specimens after being immersed in a temperature of 60º C in a Waterbath for 24 hours to the stability of the Marshall specimens with 30 minutes, commonly called an immersion index (IP) or Marshall Time Balance (residual strength index).

**Immersion index without anti-flaking additive**

IP $= \frac{\text{Marshall stability Immersion}}{\text{Marshall stability standard}} \text{x } 100\%$

$= \frac{1422}{1579} \text{x } 100\%$

$= 90\%$

**Immersion index with anti-flaking additive**

IP $= \frac{\text{Marshall stability Immersion}}{\text{Marshall stability standard}} \text{x } 100\%$

$= \frac{1765}{1886} \text{x } 100\%$

$= 94\%$

From the results of the Marshall Immertion Normal test, an immersion index of 90% was obtained and an additive of 94% was obtained. The immersion index value has met the standards set by the 2010 Research and Development Road and Bridge Research and Development Agency, which is ≥ 90%.Based on these values it can be concluded that road pavement using 0.2% Wetfix-Be additive as anti-striping in the AC-WC mixture can increase residual stability by 4.4%, so that pavement will be more resistant to temperature and duration of water immersion but must be accompanied with maintenance.

## 4. CONCLUSIONS

a) The results of the mixed performance test/ characteristics of Marshall Asphalt Concrete (AC - WC) show that the addition of the Wetfix-Be additive by 0.2% can improve the durability of the mixture and is more resistant to peeling due to the influence of weather water and vehicle loads so that the road life will last longer or increase.

b) The results of testing Marshall characteristics from the use of the Wetfix-Be additive of 0.2% of KAO in AC-WC Asphalt concrete mixtures obtained optimum asphalt levels of 5.5% with the following performance: VMA decreased by 0.59% (15.29% >15), 29%, VFB increased by 0.63% (68.48% >65%), VIM decreased by 1.87% (4.82% (3% -5%) Marshall stability increased by 19.44% (1579>800), Flow decreased by 41% (4.23 mm >2-4 mm), MQ increased by 41.47% (381 kg/mm > 250kg/mm), and Marshall Immersion increased by 4%.

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