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Influence of Number of Collisions Towards Asphalt Emulsion Mixture Stability Using Marshall Method (SNI 06-2489-1991)

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Abstract. The development of road construction in Indonesia recently increased. This resulted in demand of asphalt, which is one of the materials used in the pavement mix has also increased. Aspalt emulsion in Indonesia have been applied, but only to the adhesive layer and the absorption layer. The Public Works Department of the Directorate General Bina Marga has issued several guidelines to guide the implementation of cold mix asphalt work. The use of emulsion asphalt mixture technology which has a low temperature will reduce emissions, reduce the amount of energy consumption, and avoid oxidation. This study aims to analyze the value of the optimum asphalt content (KAO) mixture of emulsion asphalt CSS-1h and to analyze the effect of the number of collisions on the stability of the emulsion asphalt mixture. The results show that based on the relationship between the emulsion asphalt content and all Marshall and volumetric parameters, the optimum residual asphalt content is obtained. The emulsion is 5.5%. The impact of the collision on the stability value increases with the number of collisions. This test results in stability values of 1223.5 kg, 1373 kg and 1401.1 kg for normal specimens while for immersed test objects the remaining stability values are 51.7 kg, 59 kg, 68.2 kg. Based on the values obtained, this test is declared to meet the specifications for the cold mix emulsion asphalt.

1. Introduction

The development of road construction in Indonesia has recently increased. This has resulted in the increasing need for asphalt, which is one of the materials used in the pavement mixture. Asphalt emulsion in Indonesia has been applied, but only to the adhesive layer and the absorption layer. The Public Works Department of the Directorate General of Highways has issued several guidelines to guide the implementation of cold mix asphalt work. The use of emulsion asphalt mixture technology which has a low temperature will reduce emissions, reduce the amount of energy consumption, and avoid oxidation.

Many researchers have developed emulsified bitumen via cold mix asphalt. Among the research on cold asphalt mixtures are as follows, show that the use of emulsion asphalt has a high level of effectiveness in the implementation of recycling of asphalt mixtures in the field [1-3]. Shaowen Du, (2013) [4], recommends a modified cement mix method with an emulsion asphalt mixture based on the optimum choice of cement which results in increasing the asphalt binder stiffness and adhesion to the surface of the aggregate in practical applications. The waste ash in the cold asphalt mixture can increase the resistance of the material to water sensitivity and provide good resistance to fatigue [5].

The development of the amount of traffic load that will be received by the road results in the reduced service life of the pavement layer. Compressive load and tensile load are two loads that serve by a pavement layer. For compressive load, greater value can be obtained by direct Marshall test. Meanwhile, to measure the value of the load can not be tested directly because the testing tool does not yet exist. Infield conditions, it is the tensile load that often causes cracks, which begins with the initial retrieval of the lower part of the pavement layer which will then spread to the surface. However, it is difficult to get the tensile force loading that occurs in the field. So to see the tensile force of the asphalt will use the Indirect Tensile Strength Test/ITS method. This study aims to analyze the value of the optimum bitumen content (KAO mixture of emulsion asphalt CSS-1h and analyze the effect of the number of collisions on the mixture of emulsion asphalt mixture.

2. Materials and Methods

2.1. Asphalt Emulsion

The use of emulsion asphalt began in the early 20th century. Currently 5% to 10% of the grade of bitumen used is in emulsion form, but the use of emulsion asphalt varies greatly from country to country [6]. Emulsion asphalt is liquid asphalt produced by dispersing bitumen hard asphalt into air or vice versa with the help of an emulsifier. Emulsion asphalt is the result of evenly dispersing cement asphalt in water using an emulsifier that binds the asphalt molecules with water molecules. In an emulsion mixture, the asphalt content ranges from ± 55-75%. Table 1 show characteristics of asphalt emulsion CSS-1h used this research.

Table 1. Characteristics of Asphalt Emulsion

Kinds of Testing	Testing Result
Visvosity, Saybolt Furol 25°C, s	39
Storage stability, 24-h, %	0.6
Elementary Charge	Postive
Sieve Test Number. 20, %	0
Distillation	
● *Water Content, %*	36.65
● *Oil Content, %*	2.0
● *Residue Content, %*	62.35
Residue Penetration, 0.1 mm	101
Residue Ductility, cm	103
Solubility in trichloroethylene, %	99.4

2.2. Characteristics of Aggregate

Aggregates are a determining factor for the ability of road pavements to carry traffic and resistance to weather. The use of aggregate as a road pavement material needs to be considered regarding the gradation, cleanliness, hardness and resistance of the aggregate, the grain shape of the surface texture, porosity, absorption, density and adhesion of the asphalt. 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 properties of coarse aggregates, fine aggregate and filler are shown in Table 2, 3 and 4, respectively. The aggregates used for material component in cold mixture were collected from Jeneberang river in Gowa.

Table 2. Properties of Coarse Aggregate

Properties	(Crushed Stone)	
	0,5 - 1 (cm)	**1 - 2 (cm)**
Water absorption, %	2.071	2.08
Bulk specific gravity	2.622	2.627
Saturated surface dry specific gravity	2.677	2.682
Apparent specific gravity	2.773	2.779
Flakiness index, %	20.1	9.38
Abrasion aggregate, %	25.72	24.36

Table 3. Properties of Fine Aggregate

Water Absorption, %	2.792	
Sand Equivalent, %	89.66	
Bulk spesicific gravity 2.449	Saturated surface dry specific grafity 2.518	Apparen t specific gravity 2.629

Table 4. Properties of Mineral Filler

Water Absorption, %	2.283	
Sand Equivalent, %	69.57	
Bulk spesicific gravity 2.595	Saturated surface dry specific grafity 2.654	Apparent specific gravity 2.758

2.3. Combined Aggregate Gradation

The combined aggregate gradation is shown in Fig. 1. The combined aggregate gradation was kept. The mixtures were all prepared in the laboratory. Asphalt emulsion, aggregates and filler were mixed and compacted into the cylindrical mold with capacity of 1,200 gram and diameter of 101.6 mm. The specimens were compacted with 50 blows each face by using Marshall compactor. Mixing and compaction process were carried out in the laboratory at temperature room 27°C. Comparison of the composition of the aggregate between the 1-2 cm coarse aggregate, the 0.5-1 cm of crushed stone coarse aggregate and the stone dust is 19%: 54%: 27% of the aggregate composition, the proportion of the combined aggregate.

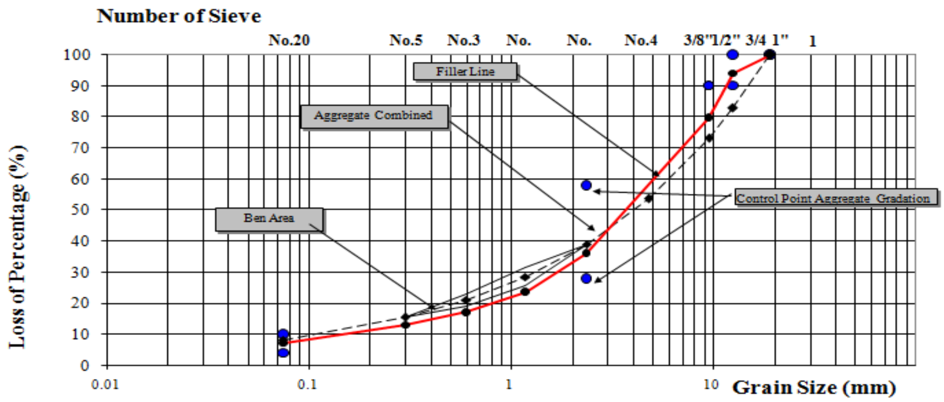

Figure 1. Combined Aggregates Gradation

2.4. Manufacture of Test Object

The test object made was 25 pieces for asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5%. The manufacture of the test object refers to the SNI Marshall, begins with weighing the components of the mixture, namely aggregate, emulsion asphalt, according to the mix design. After cold conditions, the compacted specimen is removed from the mold using an ejector. Then the specimen put in the oven for 1 x 24 hours at a temperature of 38°C Normal (Normal) but previously it was left in the mold for 1 x 24 hours. Then again make the test object which is added by the immersion process for 2 x 2 x 24 hours to obtain residual stability. But with a different curing process, the test object is left at room temperature for the specified time.

2.5. Marshall Test Method

The number of specimens prepared is determined from the purpose for which the Marshall test is performed. AASHTO determines a minimum of 3 specimens for each level of asphalt used. The basic principle of the Marshall method is stability and flow checks. The mixed design based on the Marshall method was invented by Bruce Marshall, and has been standardized by ASTM or AASHTO through several modifications, namely ASTM D 1559-76, or AASHTO T-245-90. The basic principles of the Marshall method are stability and flow checks, as well as density and pore analysis of the formed solid mixture. The Marshall tool is a pressing device equipped with a proving ring with a 22.2 KN (5000 lbs) capacity and a flow meter. The probing ring is used to measure the stability value, and the flow meter to measure the plastic melt or flow. The Marshall specimen is a cylinder with a diameter of 4 inches (10.2 cm) and a height of 2.5 inches (6.35 cm).

3. Results and Discussion

3.1. Relationship Between The Number of Collisions and The Emulsion Asphalt Mixture with VMA (Voids in Mineral Aggregate)

Figure 2 illustrates that the VMA value decreases as the number of collisions increases. This is evidenced by the VMA value at the collision of 35 which is greater than the collision of 50 and 75. The relationship graph shows the VMA values for collisions of 35.50 and 75, respectively 24.29%, 24.12%, 24.07% for normal specimens. While the immersed test object (residual) VMA values were 28.75%, 28.47%, 28.2%.

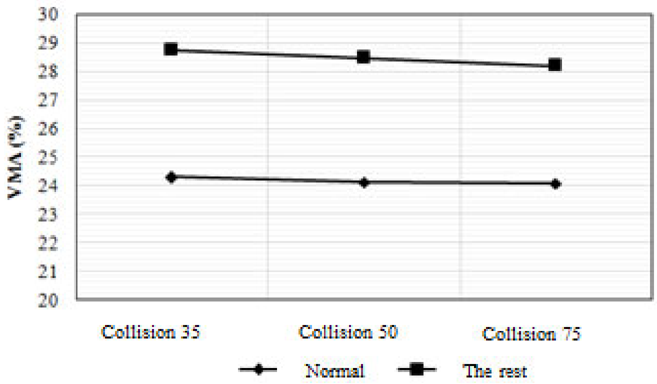

Figure 2. The relationship between number of collisions and emulsion asphalt mixture with VMA

Figure 2 shows that the VMA value is decreasing. This is because the large number of collisions makes the cavity in the mixture denser and the air cavity in a specimen is reduced. In addition, the immersed test specimen also affects the cavity in the mixture to become denser. Based on the results of this test, all specimens meet the cavity requirements between mineral aggregates (VMA) with a minimum requirement of 16%.

3.2. Relationship Between The Number of Collisions and The Emulsion Asphalt Mixture with VIM (Voids in Mix)

Figure 3 shows that the number of collisions of 35 produces a VIM value greater than the number of collisions of 50 and the number of collisions of 50 results in a VIM value greater than the number of collisions of 75, with values of 3.14%, 2.91%, 2.85% for normal specimens and a value of 8.84. %, 8.47% and 8.13% for immersed specimens.

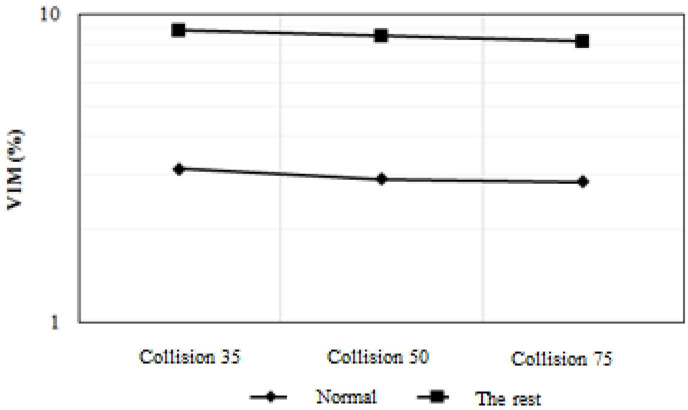

Figure 3. The relationship between number of collisions and emulsion asphalt mixture with VIM

Based on the analysis results, Figure 3 shows that the VIM value is decreasing. This is because the large number of collisions makes the air cavity in the mixture denser and further reduces the cavity in the asphalt mixture. This test shows that all specimens meet the requirements for the air cavity (VIM) based on the requirements of the VIM value specification between 3% -12%.

3.3. Relationship Between The Number of Collisions and The Emulsion Asphalt Mixture with VFB (Voids Filled Bitumen)

Figure 4 shows that the VFB value of collision 35 is smaller than the collision 50, and the collision test object 50 produces a VBA value smaller than the number of collisions 75, with values of

87.12%, 87.94%, and 88.2%, respectively. for normal specimens. Whereas for the immersed test object the VFB values were 69.26%, 70.26% and 71.2%, respectively.

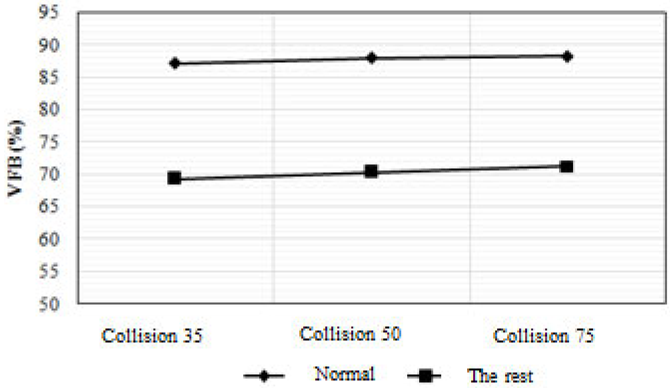

Figure 4. The relationship between number of collisions and emulsion asphalt mixture with VFB

3.4. Relationship Between The Number of Collisions and The Emulsion Asphalt Mixture with Stability

Based on the Marshall test results, the relationship between the number of collisions and the stability is shown in Figure 5. The test results show that when the number of collisions on the emulsion asphalt mixture increases, the stability value also increases until it reaches an optimum value. The following figure shows the relationship between the number of collisions in the emulsion asphalt mixture, namely when the number of collisions on the emulsion asphalt mixture. It can be seen in Figure 5 that the stability value at the collision of 35, 50 and 75 increases with the respective values of 1223.5 kg, 1373 kg and 1401.1 kg for normal test objects, while for immersed test objects the remaining stability values are 51.7 kg, 59 kg, 68.2 kg. The increase in stability value is greatly influenced by the number of collisions because in the compaction process, the number of collisions will result in friction between the aggregate grains (interlocking) and the cavities in the mixture are reduced so that the mixture becomes solid and the stability value increases to a maximum point. This experiment also explains that the emulsion asphalt mixture with collision does not meet the minimum limit of residual stability specifications. This is based on testing the residual stability value of the variation is only 51.7 kg while the specification of the residual stability value is not less than 60.

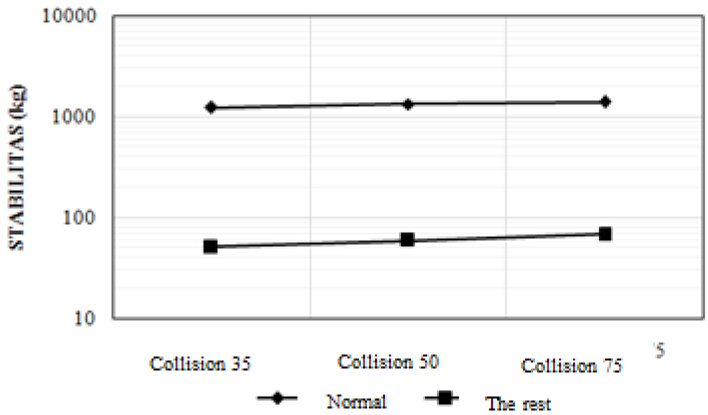

Figure 5. The relationship between number of collisions and emulsion asphalt mixture with stability

3.5. Relationship Between The Number of Collisions and The Emulsion Asphalt Mixture with Flow

Based on the results of the Marshall test, the relationship between the number of collisions and emulsion asphalt with flow is shown in Figure 6.

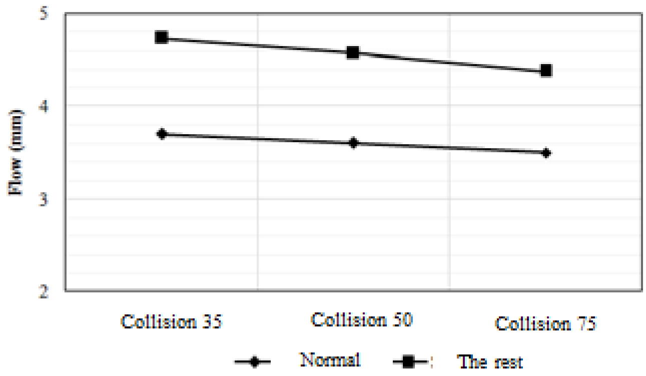

Figure 6. The relationship between number of collisions and emulsion asphalt mixture with flow

The flow values obtained did not meet all the specifications set by Bina Marga, namely 2 mm to 4 mm. This is because the lowest flow value is in the emulsion asphalt mixture with 75 collisions, with a flow value of 3.5 mm and the highest flow value in the emulsion asphalt mixture with 35 collisions with a flow value of 4.7 mm.

The flow values of the normal specimens have flow values of 4.7 mm, 4.6 mm, and 4.3 mm, respectively. Meanwhile, the immersed test specimen has a flow value of 4.7 mm, 4.6 mm, 4.3 mm. The less number of collisions will cause the fine cavity in the mixture to become denser so that the fine cavity provides the ability to be more flexible (flexibility), however the increased cavity between the mixture and the use of high emulsion asphalt content can cause the plastic melt value (flow) to increase.

3.6. Relationship Between The Number of Collisions and The Emulsion Asphalt Mixture with Marshall Quetiont

Based on the Marshall test results, the relationship between emulsion asphalt content and marshall quetiont is shown in Figure 7. The relationship between emulsion asphalt content and marshall quetiont content has a strong relationship.

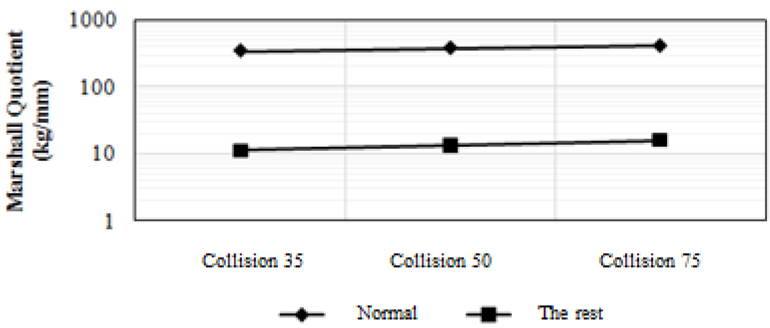

Figure 7. The relationship between number of collisions and emulsion asphalt mixture with Marshall Quetiont

The Marshal and flow test results, the relationship between the number of collisions and the Marshall Quotient are shown in Figure 7. The test results show that when the number of collisions on the emulsion asphalt mixture increases, the Marshall Quotient value also increases. In Figure 7, The Marshall Quotient value for the collision 35 is lower than the 50 and 75 collisions with the respective values of 322 kg/mm, 381 kg/mm and 401.33 kg/mm for normal specimens. Meanwhile, the immersed test specimens were valued at 11 kg/mm, 13.2 kg/mm and 15.9 kg/mm.

4. Concluding Remarks

A good adhesion between bitumen and aggregate particle arose from a good cohesion between petroleum bitumen as droplet phase in the asphalt emulsion and aggregate. The filler of stone dust contributed in the creation of a better aggregate and particle packing. As a result, asphalt emulsion containing petroleum bitumen had the sufficient stability to bear the load with flexibility deformation.

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