The Usage of Wetbond-SP and Retona Blend 55 on Hotmix Asphalt

Andronikus Mangiring¹ and Adelia Dwidarma Nataadmadja¹*

¹Civil Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia, 11480

Abstract. The flexible pavement layers are very susceptible to damage due to moisture or water. Excess moisture on any of pavement layers can cause damage before the designed pavement lifetime. To improve the quality of flexible pavement layers, modifications to asphalt mixtures are required. This study aims to compare the performance of asphaltic mixture that was constructed by using two different additives, which are Wetbond-SP and Retona Blend and by two different natural aggregates. There were three tests conducted for each sample variation in this study, namely Marshall, Cantabro Loss, and Indirect Tensile Strength (ITS) tests. From the test results, it was found that adding the Retona Blend 55 to the asphaltic mixture resulted in better Marshall, Cantabro Loss, and ITS test results compared to the asphaltic mixture that was mixed with Wetbond-SP.

1 Introduction

Completeness of the transport network can often be used as a benchmark for the level of progress of a region. The better the transport network in a region, the higher the value of land in the region will be. In accordance with its role in economic development, transportation networks can also trigger development, this must be balanced with the existence of adequate infrastructure (roads)[1]. Therefore, in planning the road must meet the criteria of durable, strong, safe, comfortable, inexpensive. The high need for road access due to the increasingly increasing movement, adequate road access is needed, as a support for the achievement of optimal movement, both in terms of quality, quantity, and accessibility [2].

However, roads often reach damage before reaching the planned life, the factors that cause road damage are due to high air temperatures, overloading, and water [3]. To prevent such damage, the hot asphalt mixture can be added with additives. There are a number of available additives that can be used as anti-stripping agent [4], that would prevent moisture to infiltrate onto asphaltic mixture, such as amine-based antistripping agent (ASA)[5], Zycotherm® [6], Crumb Rubber (CR), and Styrene-Butadiene-Rubber (SBR) [7]. In this study will evaluate the use of Retona Blend 55 which serves as a binder in asphalt mixtures that can anticipate premature damage that occurs on road sections that serve heavy traffic loads and high temperatures [8]. Wetbond-SP which serves to transfer water in the aggregate during the initial mixing stage of hot mix construction when the aggregate is added to the drying drum, moisture can prevent asphalt residues from the aggregate layer, by having an optimum level of usage of 0.3-0.5% [2], [9].

Retona Blend 55 is the name of a mixture of asphalt pen 60, asphalt pen 80 and asphalt from Buton Island, Indonesia [10]–[12]. Subsequently, each variation of the usage of Retona Blend 55 is compared to penetration asphalt to determine its effects. The mixture in Retona Blend 55 consists of 20% Retona Blend serves as both asphalt and void filler in asphalt mixtures, aiming to enhance the performance of hot asphalt mixtures and prevent premature damage on road sections that endure heavy traffic loads and high temperatures. The characteristics of Retona Blend 55 are easy to use, longer service life, and can serve high traffic [13]–[15]. In this study, will examine the use of aggregates from two different sources and will be mixed with asphalt Shell which is added additives in the form of Wetbond-SP and will be compared with Retona Blend 55 in hot asphalt mixture AC-WC.

2 Research Methodology

Figure 1 shows the flow of this research. The initial stage in this study was to conduct the literature review to determine the type of aggregate and the type of additives used to achieve the objectives of this study. It was determined that there were two aggregates and two types of additives used in this research. Before the asphaltic mixture specimens were constructed, all the materials were tested for their suitability to be used as asphaltic mixture ingredients. The size and composition of the aggregates used are in accordance with Table 1.

* Corresponding author: adelia.nataadmadja001@binus.ac.id
Fig 1. Research Methodology

Table 1. Aggregate Size Used

<table>
<thead>
<tr>
<th>Type</th>
<th>Sieve No</th>
<th>Passed</th>
<th>Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate 1</td>
<td>0.75 (19.1 mm)</td>
<td>0.375 (9.6 mm)</td>
<td></td>
</tr>
<tr>
<td>Aggregate 2</td>
<td>0.375 (9.6 mm)</td>
<td>#8 (2.4 mm)</td>
<td></td>
</tr>
<tr>
<td>Aggregate 3</td>
<td>#8 (2.4 mm)</td>
<td>#16 (1.2 mm)</td>
<td></td>
</tr>
<tr>
<td>Aggregate 4</td>
<td>#16 (1.2 mm)</td>
<td>#200 (0.075 mm)</td>
<td></td>
</tr>
</tbody>
</table>

2.1 Laboratory tests

There were three laboratory tests conducted in this research, namely the Marshall test, the Cantabro test and the Indirect Tensile Strength (ITS) test. Each test was repeated three times to obtain a statistically significant result. The Marshall test was conducted to determine the quality of the asphalt mixture based on SNI.06-2489-1991. There were some parameters that would be generated from this test, which are stability, flow, Void in Mixture (VIM), Void Filled with Bitumen (VFB), Void in Mineral Aggregate (VMA), density, and Marshall Quotient (MQ).

The Cantabro test is a test to determine the loss of abrasion of prepared asphalt specimens [16]. The results of the Cantabro test can be represented as Cantabro Abrasion Loss (CAL) which can be calculated with the following equation:

\[
CAL = \left( \frac{m_1 - m_2}{m_1} \right) \times 100\% \quad (1)
\]

Object :
CAL = Cantabro Abrasion Loss (%)

m1 = The weight of the original test object (gr)
m2 = The weight of the different after testing (gr)

The ITS test is a test to determine the ratio of the stability or the strength of a sample when the sample is at dry condition to when the sample is at wet condition [17]. ITS test was done by immersing the test specimen in water for 24 hours to represent the wet condition and for 30 minutes at 60°C to represent the dry condition (AASHTO T-283). The value of Tensile Strength Ratio (TSR) states the value of asphalt mixture's resistance to moisture damage. Where the equation to get the value of ITS is as follows:

\[
ITS = \frac{2 \times P}{\pi \times D \times t} \quad (2)
\]

where
P = The maximum load that a sample can accept (N)
D = The diameter of the sample (mm)
t = Thickness of the sample (mm)

To get the results from the TSR requires the results of ITS calculations, where the equation used to get the TSR results is as follows:

\[
TSR = \frac{ITS_{\text{sat}}}{ITS_{\text{dry}}} \quad (3)
\]

where
ITS\text{sat} : ITS value with 24-hour immersion at 60°C
ITS\text{dry} : ITS value with 30 minutes immersion at 60°C

3 Results and Discussion

3.1 Aggregate Test Results

Each aggregate was tested for their suitability before being used. The test results of aggregate 1 and aggregate 2 are shown in Table 2 and Table 3 respectively. It can be seen from the test results that both aggregates have met all the requirements set by the standards used, and hence, suitable to be used as an ingredient for asphalt mixture.

Table 2. Aggregate Test Result 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Requirement</th>
<th>Aggregate 1</th>
<th>Aggregate 2</th>
<th>Aggregate 3</th>
<th>Aggregate 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity</td>
<td>≥ 2.5 gr/cc SNI 1969</td>
<td>2.552</td>
<td>2.538</td>
<td>2.527</td>
<td>2.525</td>
</tr>
<tr>
<td>Surface Dry Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparent Specific Gravity</td>
<td>≥ 2.5 gr/cc SNI 1969</td>
<td>2.603</td>
<td>2.604</td>
<td>2.714</td>
<td>2.773</td>
</tr>
<tr>
<td>Absorption</td>
<td>Max 3% SNI 1970</td>
<td>1.980%</td>
<td>2.617%</td>
<td>1.999%</td>
<td>2.606%</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>Max 40% [18]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>26.950%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Aggregate Test Result 2

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Requirement</th>
<th>Aggregate 1</th>
<th>Aggregate 2</th>
<th>Aggregate 3</th>
<th>Aggregate 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Specific Gravity</td>
<td>≥ 2.5 gr/cc SNI 1969</td>
<td>2.746</td>
<td>2.513</td>
<td>2.526</td>
<td>2.526</td>
</tr>
<tr>
<td>Surface Dry Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparent Specific Gravity</td>
<td>≥ 2.5 gr/cc SNI 1969</td>
<td>2.789</td>
<td>2.548</td>
<td>2.825</td>
<td>2.825</td>
</tr>
<tr>
<td>Absorption</td>
<td>Max 3% SNI 1970</td>
<td>1.541%</td>
<td>1.405%</td>
<td>2.923%</td>
<td>2.859%</td>
</tr>
</tbody>
</table>
3.2 Binder Test Results

There were two types of binder being used herein, namely asphalt with penetration 60/70 that was sourced from Shell and Retona Blend 55. Same with the aggregates, both binders were also tested before being used. The test results can be seen in Tables 4 and 5. It is important to note that the Retona Blend 55 has different penetration limit than the other binder. It can be seen that both binders satisfy the requirements set by the standards used, and hence suitable to be used in the asphalt mixture.

Table 4. Test Results for Asphalt Pen 60/70

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Specification</th>
<th>Required Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration</td>
<td>0.1mm</td>
<td>SNI 2456-1991</td>
<td>60-70</td>
<td>68</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>gr/cc</td>
<td>SNI 2441-1991</td>
<td>MIN 1.0</td>
<td>1.242</td>
</tr>
<tr>
<td>Ductility</td>
<td>cm</td>
<td>SNI 2432-1911</td>
<td>MIN 100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Softening Point</td>
<td>°C</td>
<td>SNI 2434-1991</td>
<td>MIN 100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Flash Point</td>
<td>°C</td>
<td>SNI 2433-1991</td>
<td>MIN 232</td>
<td>315.3</td>
</tr>
<tr>
<td>Softening Point</td>
<td>°C</td>
<td>SNI 2433-1991</td>
<td>MIN 232</td>
<td>320.4</td>
</tr>
</tbody>
</table>

Table 5. Test Results for Retona Blend 55

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Specification</th>
<th>Required Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration</td>
<td>0.1mm</td>
<td>SNI 2456-1991</td>
<td>40-55</td>
<td>53</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>gr/cc</td>
<td>SNI 2441-1991</td>
<td>MIN 1.0</td>
<td>1.11</td>
</tr>
<tr>
<td>Ductility</td>
<td>cm</td>
<td>SNI 2432-1911</td>
<td>MIN 100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Softening Point</td>
<td>°C</td>
<td>SNI 2434-1991</td>
<td>MIN 100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Flash Point</td>
<td>°C</td>
<td>SNI 2433-1991</td>
<td>MIN 232</td>
<td>272.1</td>
</tr>
<tr>
<td>Softening Point</td>
<td>°C</td>
<td>SNI 2433-1991</td>
<td>MIN 232</td>
<td>275.5</td>
</tr>
</tbody>
</table>

3.3 Research Variation

Table 6 shows the variation of the asphalt specimens constructed. In total, there were six variations. The control samples were the ones without any additives. The ones denoted as W1 and W2 were mixed with 0.5% Wetbond-SP [19] and the ones denoted as R1 and R2 were mixed with Retona Blend 55 as the binder.

Table 6. Research Variation

<table>
<thead>
<tr>
<th>Additives</th>
<th>Aggregate 1</th>
<th>Aggregate 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (Control)</td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Wetbond-SP</td>
<td>W1</td>
<td>W2</td>
</tr>
<tr>
<td>Retona Blend 55</td>
<td>R1</td>
<td>R2</td>
</tr>
</tbody>
</table>

3.4 Optimum Asphalt Content (OAC) Test Result

The OAC was determined to know the percentage of asphalt content to be used in the manufacture of asphalt samples combination. OAC value on the use of asphalt penetration 60/70 obtained can be seen in Figure 1 for OMC asphalt mixture with aggregate 1 and Figure 2 for OAC asphalt mixture with aggregate 2.

Based on Figure 2 and Figure 3 shows that the optimum asphalt content of asphalt mixture with aggregate 1 is at 5.6% and the optimum asphalt content of asphalt mixture with aggregate 2 is at 5.5%.

The value of OAC on the use of Retona Blend 55 obtained can be seen in Figure 4 for OAC asphalt mixture with aggregate 1 and Figure 5 for OAC asphalt mixture with aggregate 2.
can increase the stability values of asphalt specimens prepared by both aggregates and using Retona Blend 55 able to improve the stability values of specimens seen that adding Wetbond-SP onto the specimen was than the ones prepared with aggregate 1. It can also be aggregate, the stability of the asphalt mixture will also level of hardness or easily destroyed, will results in the aggregates that make it up. Aggregates that have a weak in influenced by how the degree of hardness of the 3.5 Marshall Test Result Stability is the maximum load that can be accepted by the asphalt mixture until the occurrence of cracks, stability is expressed in kilograms (kg). The 2010 Revised 3 Binamarga Specifications Division 6, the minimum limit value of stability on normal asphalt ≥800 kg and the minimum limit value of stability on asphalt that has been modified is ≥1000 kg. Figure 6 shows the stability value of the use of natural asphalt and asphalt pen 60/70 modified using additives to aggregate 1 and 2.

The stability of the asphalt mixture is greatly influenced by how the degree of hardness of the aggregates that make it up. Aggregates that have a weak level of hardness or easily destroyed, will results in the low stability value. It is necessary to select aggregates of good quality. The stronger the hardness of the aggregate, the stability of the asphalt mixture will also be greater. This shows that the stability value of the asphalt mixture made in aggregate 1 has a greater value than the value of aggregate 2.

It can be seen that the stability of the specimens prepared with aggregate 2 has a slightly lower value than the ones prepared with aggregate 1. It can also be seen that adding Wetbond-SP onto the specimen was able to improve the stability values of specimens prepared by both aggregates and using Retona Blend 55 can increase the stability values of asphalt specimens even higher for both aggregates.

Figure 7 shows the flow values for all specimen variations. Flow value is the value of the flexibility of the asphalt mixture to withstand traffic loads expressed in units of millimeters (mm). According to the General specification of Binamarga 2010 Revision 3 Division 6, the limitation value of flow is 2-4 mm.

In Figure 7, shows that the flow value of all asphalt mixtures have met the applicable restrictions according to the specifications of Bina Marga (2010), which is 2-4 mm. The flow value of the asphalt mixture with Wetbond-SP increases stiffness and brittle but does not make the asphalt mixture brittle, while a high flow value with low stability will have plastic properties that cause the mixture to deform easily when receiving loads. As for Retona Blend 55, it does not show a significant impact, but still within the allowable limits.

Figure 7 shows that the asphalt mixture with aggregate 1 has a higher flow value than the ones with aggregate 2 for both additives. The flow value can be influenced by several factors such as gradation, asphalt content, shape and aggregate surface. If the aggregate as a constituent of the mixture has a weak level of hardness or easily destroyed, then the mixture will be easier to melt as a result of the relationship or bond between each grain of aggregate with asphalt which will further reduce the value of the flow.

Figure 8 shows the VIM value, which represents the percentage value of the air space between the aggregate particles covered by asphalt expressed in percent (%). According to the General specification of Binamarga 2010 Revision 3 Division 6, The limitation value of VIM is 3% - 5.5%.

It can be seen that VIM values on all asphalt mixtures have met the specifications. The value of VIM on asphalt mixture using two aggregate sources showed a decreasing value on Wetbond-SP and Retona Blend 55 asphalt mixture. A high value of VIM can cause brittleness due to compaction caused by traffic loads, while the best value of VIM is in the asphalt mixture that has the lowest value of VIM found in the aggregate test specimen 2, with the use of Retona blend 55 asphalt in aggregate 2 of 3.049%. Low VIM value makes the cavity between the aggregate grains will be less so that the mixture becomes denser this causes water and air tidah easily enter the cavity in the asphalt mixture. The use of Retona Blend 55 is useful so that the asphalt is not easy to bleed if the temperature increases. In Figure 7, shows that the aggregate quality affects the value of
VIM. This proves that increasing the percentage of asphalt content in the composition of the mixture will reduce the value of voids in the mixture (VIM).

Figure 8. Comparison of VIM Values for All Variations

Figure 9 shows the value of VFB, which is part of the VMA that is filled by asphalt, not including asphalt absorbed by each aggregate grain. VFB serves to envelop the aggregate grains in solid asphalt concrete, the value of VFB is expressed in percent (%). According to the General specification of Binamarga 2010 Revision 3 Division 6 the minimum limitation value of the VFB is >65%.

It is shown that the value of VFB on all asphalt mixtures have met the specifications of highways (2010), namely 65 %. The addition of Wetbond-SP by 0.5% was able to increase the results of VFB value, it is in accordance with previous research [2]. A large VFB value indicates if the aggregate surface and air cavities in the aggregate were well covered with asphalt.

The data shows that the asphalt mixture using aggregate 2 has a greater VFB value than the asphalt mixture using aggregate 1. This is due to the influence of more levels of asphalt in the mixture, then the volume of the cavity between the grains of aggregate will be greater.

Figure 10 shows the density value for each variation. The addition of anti-stripping agent and aggregate type has no effect on the density value, where the density value does not change in any type of asphalt mixture or aggregate type.

The results show that the value of VMA on all asphalt mixtures have met the specifications of highways (2010). The minimum value of VMA is useful to avoid the many air cavities that cause the material to become porous. Pore cavities in aggregate minerals depend on grain size, arrangement, shape and compaction method. It can be seen that the aggregate type matters, especially when additive was added. It can be seen that the VMA values decrease for specimens mixed with aggregate 1 as Wetbond-SP was added and even lower as Retona Blend 55 was used. For the samples mixed with aggregate 2, the VMA of the sample decreased when Retona Blend 55 was used.

Figure 11 shows the MQ value for each variation. This parameter was obtained by comparing the stability value against the flow value. MQ is a parameter that indicates the stiffness value of a paved mixture in receiving loads. The MQ value is expressed in kilograms per millimeter (kg/mm), the terms of the MQ value in accordance with the general specifications of Binamarga 2010 Revision 3 Division 6, namely 250kg/mm.

The data shows that the value of MQ on all asphalt mixtures have met the specifications. The addition of anti-stripping agent affects the increase in the value of MQ. The MQ value increases due to increased stability value and the value of Flow drops in asphalt mixture Wetbond-SP and Retona Blend 55. The stiffer a mixture the higher the MQ value. The addition of Wetbond-SP
by 0.5% increased the value of MQ in aggregate 2 by 350,557 kg/mm. While the highest results for the value of MQ obtained at Retona Blend 55 on aggregate 2 of 386.660 kg/mm.

Additionally, the type of aggregate affects the change in the value of MQ. The value of MQ in aggregate 2 has a greater value than the value of MQ in aggregate 1.

3.6 Cantabro Loss Test Results

The test results shown in Figure 13 shows that the addition of Wetbond-SP decreased the value of CA. This is because the addition of additives that are able to make the adhesion of the asphalt mixture stronger. In Retona Blend 55 has the best results for Cantabro Loss with the lowest value among others at 5.09%.

The effect of the type of aggregate in the Cantabro Loss test can be seen from Figure 13, where the value of Cantabro Loss in aggregate 2 tends to be greater than aggregate 1. This is because the wear and absorption of aggregate 1 is lower than that of aggregate 2. The value of Cantabro Loss on each test object has met the requirements, namely the value of Cantabro Loss ≤20%.

3.7 ITS Test Results

TSR values obtained from the comparison of the value of its in the dry state with the value of ITS in the wet state, the lower the value of TSR indicates that the asphalt mixture is more susceptible to water. The TSR value is expressed in Percent units (%). The minimum TSR requirement is 80% as stated in AASHTO T-283. A TSR value of less than 80% indicates that the asphalt mixture is susceptible to damage caused by water, while a TSR value of more than 80% indicates that the mixture is resistant to damage caused by water. In Figure 14, each shows the TSR value of the effect of the use of asphalt Retona Blend 55 and Wetbond-SP on aggregate 1 and aggregate 2.

Figure 14 shows that the addition of the use of Retona Blend 55 affects the TSR value, this is in accordance with the results shown in [20] that Retona Blend can improve the quality and quality of asphalt mixtures. The higher the TSR value obtained on the test object, the more resistant to damage caused by water. Retona Blend 55 TSR value on asphalt content of 5.365% get the highest TSR value on asphalt mixture on aggregate 1 is 92.72%. As for the asphalt mixture using aggregate 2, Retona Blend 55 at 5.42% gives the best TSR results of 97.9%. TSR value is strongly influenced by the comparison of its wet value divided by its dry value.

The data shows that the type of aggregate affects the value of TSR, where the value of TSR in asphalt mixture using aggregate 2 bonds between aggregates will be stronger in accepting the load vertically and will have a better ability to maintain the decline.

TSR value due to temperature and humidity. tend to be lower than the aggregate 2. This is caused by water which causes a decrease in the strength of the bond between the aggregate and the asphalt, so that the tensile strength is reduced. The decrease in adhesion caused by this water will reduce the cohesiveness of the mixture, so that the strength of the mixture will decrease along with it.

4. Conclusions and Suggestions

4.1 Conclusions

From the results of research that has been obtained on the comparative analysis of the quality of hot asphalt mixture with the addition of additives Wetbond-SP and Retona Blend 55 can be concluded that:

a. Asphalt mixture using aggregate 1 has better quality compared to aggregate 2. This is because the value of wear on the use of aggregate 1 has a better value than the use of aggregate 2 which has a fairly high wear value. Aggregate greatly affects the quality of the asphalt mixture, the better the quality of the
aggregate used, the greater the value of the asphalt mixture.
b. The design of asphalt mixture added by Wetbond-SP by 0.5% can increase the stability value by approximately 15% of the stability value of the control asphalt mixture, because Wetbond-SP can increase the bond between asphalt and aggregate, thereby preventing stripping (grain release). The same thing is found in the design of the mixture that added Retona Blend of 5.365% in aggregate 1 and 5.42% in aggregate 2. Based on the results of the Marshall Test, Cantabro Loss Test, and Indirect Tensile Strength, it was found that the asphalt mixture with the addition of Retona Blend 55 as large as 5.365% in aggregate 1 and 5.42% in aggregate 2 showed an improvement in the quality of the hot asphalt mixture.

4.2 Suggestions

For researchers who will continue this research, the author will give some suggestions so that better results can be obtained. The suggestions in question are as follows:
a. The asphalt mixing and compaction process should be carried out with appropriate equipment, namely a mortar mixer and a gyratory compactor to obtain a homogeneous specimen.
b. Performing further analysis of aggregates so that minerals or components that play a role in improving aggregate quality can be identified.
c. Comparing Retona Blend 55, Wetbond-SP with other natural additives and with other materials that are more economical.
d. Using waste material as a substitute for aggregate.

References


