THE EFFECT OF USED OIL MIXING VARIATIONS AND CURING TIME TO THE STABILITY OF RECYCLED ASPHALT MIXTURE

Hendi Bowoputro, Ludfi Djakfar, Muhamad Iqbal Muslim, Taqwa Rizaldi

Brawijaya University, Faculty of Engineering
Department of Civil Engineering

ABSTRACT

The aim of this research is to determine the relationship pattern between the variation in levels of used oil and curing time to Marshall Stability of recycled asphalt mixture, and to determine levels of used oil and curing time were used to obtain the optimum stability of recycled asphalt mixture. Asphalt recycled used in this research is from asphalt pavement milling in front of the Head Office of Brawijaya University. Marshall test is used to test recycled asphalt mixture with a content rate of 4%, 5%, 6%, 7%, 8% used oil and curing time 4 until 7 days. Test result indicated that the value of stability decreased with increasing levels of addition of used oil, but at 8% content of used oil, stability increased although it’s not significant. Stability value increases with increasing levels of curing time, but at the 5th day of curing time, the stability is decreased although it’s not significant. The optimum levels of used oil is 4.0%. Optimum curing time is 7 days.

Keywords: asphalt recycled, used oil, curing time

INTRODUCTION

The load and volume of vehicle are tend to grow so we need an innovation in the field of road maintenance in order to maintain or increase the design life of the road to serve traffic load. It was recognized that a strong infrastructure is needed to recover economy and good road is a very vital part of the infrastructure. If funds are not sufficient then more effective and efficient method of road rehabilitation must be obtained. Road improvement by way of adding additional layers continuously will result in pavement layer thickness is getting thicker and the material needed is thinner.

It is required method for finding an alternative development innovation that can increase the effectiveness of the use of existing cost, which is by pursuing more roads that rehabilitated of the costs incurred. Recycling method is one way to overcome this problem. Treatment with pavement recycling technology is an alternative to solve this problem because it has several advantages such as to restore pavement’s strength and maintain the road’s geometric and overcome dependence of new material.

After proclaiming about asphalt recycling, the Government through PP No. 18 Year 1999 about Managing Dangerous and Toxic Materials also about B3 waste problem which can be threat for environment. Considering natural environment’s preservation need to be maintained, so it can support the implementation of advanced constructions. By the increasing of development in all fields, especially industrial development, the amount of waste gained is increasing including the dangerous and toxic for environment and people’s health.

One of B3 waste which can be environmental problem if it is not well-
managed is engine’s used oil. The large amount of used oil which have not well-managed forces some irresponsible people to throw used oil waste anywhere, in which can cause environmental pollution which is dangerous for environment and people’s health.

By government’s warning to utilize recycled pavement material for the creation of alternative infrastructure development innovation and a lot of problems occur which are caused by the unwell-managed used oil waste, then an idea arises to utilize both. Used oil waste can be utilized as recycled asphalt’s fluxing, which can be an alternative for economic, effective, and environment-friendly infrastructure development.

**RESEARCH METHOD**

The steps of this research are:

**a. Core Drill Sample Taking**

Core drill sample taking aims to take pavement’s structure in its initial condition to investigate the parameters needed for specimen’s production. Core drill sample taking was conducted in front road of Universitas Brawijaya’s Rectorate Building.

**b. Core Drill Sample Testing**

The sample testing was conducted to find recycled asphalt’s characteristics which will be used as specimen’s production’s planning base. This testing includes Marshall Test, extraction test, sieve analysis, and testing of asphalt density.

**c. Determination of Used Oil’s Level**

Besides using related researches as parameter, before the study began preliminary research has been done associated with the determination of used oil to be used.

**d. Research’s Total Specimen**

For Marshall test used 5 test specimens for each level of oil and 5 test specimens for each curing time, so the total number of test specimens is 100 test object.

**e. Ingredients**

Recycled asphalt used in this research is recycled asphalt from the dredging by using a milling tool on the road in front of Brawijaya University Rectorate. Used oil that is used in this research is the type of used automatic transmission car engine synthetic oil.

**f. Equipment**

The equipment used is a set of compaction equipment, curing equipment, and Marshall Testing equipment.

**g. Making Specimen**

Specimens were made with used oil content variation 4%, 5%, 6%, 7%, and 8% of the asphalt content, while the curing time is 4 days, 5 days, 6 days, and 7 days.

The steps of making specimen are as follows:

1. Preparing recycled asphalt in accordance to the mixture composition to be used.
2. Mixing used oil into recycled asphalt in accordance with used oil’s level that has been planned.
3. Curing recycled asphalt mixture which has been mixed with used oil with the curing time that has been planned.
4. The mixture was compacted with Marshall Compaction in temperature of 120°C, with the total hit 2 × 75 times
5. The specimen was taken out by using extruder.

**h. Testing Specimens**

The test at this stage is to obtain stability data and the flow of recycled asphalt mixture. Marshall Test’s stages are as follows:

1. The specimens were weighed in dry condition and measured the height.
2. The specimens were soaked in water for 24 hours.
3. After being soaked, the specimens were SSD weighed and its weight in the water.
4. The specimens were put into \textit{water bath} in the temperature of 60°C for 30 minutes.

\textbf{i. Data Analysis}

In analyzing the data used trendline graphs approach, three-dimensional chart, and statistical analysis of multiple linear regression.

\textbf{RESULTS AND DISCUSSION}

\textbf{Table 1. Marshall test}

<table>
<thead>
<tr>
<th>No</th>
<th>Code</th>
<th>Marshall Test Specimens</th>
<th>Stability</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>471</td>
<td>22</td>
<td>530</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>472</td>
<td>26</td>
<td>530</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>473</td>
<td>20</td>
<td>575</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>474</td>
<td>26</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>475</td>
<td>22</td>
<td>725</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>571</td>
<td>22</td>
<td>730</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>572</td>
<td>23</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>573</td>
<td>20</td>
<td>625</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>574</td>
<td>26</td>
<td>490</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>575</td>
<td>23</td>
<td>580</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>671</td>
<td>23</td>
<td>650</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>672</td>
<td>20</td>
<td>445</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>673</td>
<td>15</td>
<td>565</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>674</td>
<td>18</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>675</td>
<td>23</td>
<td>620</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>771</td>
<td>18</td>
<td>580</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>772</td>
<td>20</td>
<td>555</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>773</td>
<td>21</td>
<td>565</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>774</td>
<td>18</td>
<td>690</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>775</td>
<td>18</td>
<td>695</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>871</td>
<td>13</td>
<td>540</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>872</td>
<td>14</td>
<td>488</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>873</td>
<td>18</td>
<td>538</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>874</td>
<td>17</td>
<td>448</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>875</td>
<td>22</td>
<td>462</td>
<td></td>
</tr>
</tbody>
</table>

\textbf{Table 2. Anova result}

\textbf{ANOVA}

<table>
<thead>
<tr>
<th>el</th>
<th>Sum of squares</th>
<th>df</th>
<th>Average Squares</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>15867.507</td>
<td>2</td>
<td>7933.753</td>
<td>9.965</td>
<td>.000</td>
</tr>
<tr>
<td>Remnant</td>
<td>73249.819</td>
<td>92</td>
<td>796.194</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>89117.326</td>
<td>94</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textbf{Table 3. Coefficient}

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficient</th>
<th>Standard Coefficient</th>
<th>Std. Error</th>
<th>Beta</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>213.041</td>
<td>18.860</td>
<td>11.296</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curing time(day)</td>
<td>5.321</td>
<td>2.558</td>
<td>.197</td>
<td>2.080</td>
<td>.040</td>
<td></td>
</tr>
<tr>
<td>Used oil Level(%)</td>
<td>-8.269</td>
<td>2.072</td>
<td>-.377</td>
<td>-3.992</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>

The relation of stability with used oil variations and permanent curing time are sequenced from the oil level of 4-8%. The bigger used oil level, the lower stability’s value, but in curing time of 4 and 5 days the stability increased to oil lever of 6-8%.

The relation of stability and variation of curing time and permanent used oil level are sequenced from the curing time 4-7 days. The longer curing time, the bigger stability value. But in used oil level of 8%, the stability decreased up to curing time of 5-6 days and back to increase up to curing time of 7 days.

\textbf{Analysis of Relationship Between Variables and Multiple Linear Regression Statistical Analysis}

The table shows that F count is 9,965 with the signification of 0.00. Because the signification is smaller than 0.05, it can be concluded that regression coefficient for the variables of used oil level and curing time are significant, which means both variables are simultaneously affect stability. The table shows that coefficient of used oil variation and curing time are -8,269 and 5,321. Based on the result, it can be concluded that the independent variables of used oil level and curing time affect stability’s dependent variable with the equation as follow:

\[ NS = 213.041 - 8.269 \text{KOB} + 5.321 \text{WP} + \varepsilon \]
From the equation, it can be concluded that:
1. Positive Coefficient of Constanta claims that by assuming inexistence of other independent variable, then the other stability value tend to increase.
2. Negative coefficient regression of claims that by assuming inexistence of other independent variables, if the value of KOB increased, then NS tend to decreased.
3. Positive Coefficient Regression of WP claims that by assuming inexistence of other independent variables, if the value of WP increased, then the value of NS will be increased.

**Calculation of Used Oil Level and Optimum Curing Time.**

In calculating used oil level and curing time which obtain optimum stability value, a regression equation of previous data analysis’s result is used an equation of three-dimensional graph, with the equation as follow:

\[
\text{Stability} = 317.6924 - 34.2075X - 16.0756Y + 6.0784X^2 - 3.6479XY + 2.408Y^2
\]

Stability : Specimens Stability Value
X : Curing time (Day)
Y : Used Oil Level (%)

From the equation, the value of X and Y will be found which obtain the most optimum stability value. By inputting X value from 4-7 days, and inputting Y value from 4-8% with interval of 0,1, the most optimum stability score will be found. Then, after the optimum stability score is found, taken used oil level with the interval of 0,01 and optimum curing time to determine optimum stability. From the calculation, obtained optimum stability in used oil level 4,0% and 7 days curing time.

**CONCLUSION AND SUGGESTION**

**a. Conclusion**

The relationship between the level of used oil and the value of stability is inversely proportional, where the value of stability decreased along with increasing levels of used oil addition, but in the 8% used oil level the value of stability increases although not significant. While the relationship between the value of the stability and curing time is directly proportional, where the value of stability increases with the increasing curing time, but at the time ripened 5 days, the value decreased stability although the decrease was not significant. The level of optimum used oil which produce the highest stability value is 4,0%.

Optimum curing time which produces the highest stability value is in 7 days of curing.

**b. Suggestion**

The use of used oil in recycled asphalt should be added with other material which can soften the asphalt so the aggregate can be banded well, because by only using used oil without adding other material cannot soften the asphalt maximally, so the aggregate cannot be banded properly.

In this research, there are quite large cavities in the specimens, the VFB value is small in average of 30,77% and quite big VIM value in average of 22 %, so if it is used for further research, it is needed to add filler so the cavity in the specimen will not be too large.

For the usage of cold mixture method, it would be better if it is not be done for the further research if only using used oil, because this method is not optimal enough to bound aggregate.
Need further researches with longer curing time, considering in this research the stability value is increasing along with the curing time.

Need further research about effective curing time method for field implementation, considering this research was conducted in laboratory where the environmental condition can be set.

Need further research pertain to environmental impact which is caused by used oil material in recycled asphalt mixture.

REFERENCES
Badan Penelitian dan Pengembangan PU, Kementerian Pekerjaan Umum, Standar Nasional Indonesia, Tata Cara Pelaksanaan Lapis Asbuton Agregat (LASBUTAG), SNI 03-2852-92.