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Deformation Velocity Analysis on Hot Asphalt Mixture Using Wire Mesh Layer as Reinforcement

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ABSTRACT-- *Damage that occurs in Flexible Pavement is mostly caused by the repetition of the load or trajectory of the vehicle's wheels under extreme conditions. The cause of the damage is due to the strength of flexible pavement which is very dependent on temperature. To overcome the problem of permanent deformation (rutting) due to repetition of load and temperature, the right method is needed to hold the deformation speed. The use of wire mesh layers is thought to be able to overcome this because of the checkered patterns on wiremesh. The purpose of this study is to analyze the velocity of the channel deformation that occurs in the surface layer of a hot asphalt mixture using a wire mesh layer as a reinforcement layer. The study was conducted with an experimental method by making 4 variations of modeling of wire mesh placement on a hot asphalt mixture using a wheel tracking machine. Based on the results of the study, it was found that the hot asphalt mixture with 20 mm wire mesh laying from the surface of the test specimen is the best modeling type with a deformation velocity value of 0.0134 mm/minute and a deformation depth of 2.194 mm. The worst modeling was obtained on a hot asphalt mixture by laying a 30 mm wire mesh from the surface of the test object with a deformation velocity value of 0.0409 mm/minute and a deformation depth of 6.507 mm.*

Keywords-- *wire mesh, deformation speed, rutting*

I. INTRODUCTION

Road construction in Indonesia, Aceh Province as one of the provinces in Indonesia generally uses hot mix asphalt as a surface layer of pavement [1]. Damage and fatigue of the hot asphalt mixture increases and depends on humidity and temperature. In extreme conditions and with a repetitive load on the surface layer of flexible pavement will cause permanent deformation (rutting)[2–7].

Road damage in Indonesia is not only caused by high traffic volume but also due to a combination of traffic loads with environmental factors which can be in the form of grooves, waves, plastic deformations and cracks [6,7].

Traffic load parameters such as temperature, static loading conditions, and vehicle speed not only affect rutting depth, but also accelerate rutting rate, causing pavement that previously entered into rutting failure with a shorter

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lifetime [2–4,6]. Rutting is a permanent deformation that occurs when the asphalt mixture changes shape when it is loaded and then does not recover back to its original position (unrecoverable) [7].

The design of the surface layer in a flexible pavement in the form of a good hot asphalt mixture is needed so that the road can operate to serve traffic during the planned life without the need for heavy repairs to the road [8]. The use of wire mesh layers in hot asphalt mixtures is considered able to withstand the rate of deformation due to repeated loads.

The aims of this study is to analyze the velocity of the channel deformation that occurs in the surface layer of the hot asphalt mixture by using a wire mesh layer as a reinforcement layer

This research was conducted by an experimental method using reinforcement material in the form of layers of wire mesh. The wire mesh used is 2 mm in diameter with 20 mm hole dimensions as a miniature conversion of Wiremesh M4.

In an effort to get accurate results in the analysis, 4 types of wire mesh laying modeling in hot asphalt mixture were made. The modeling included: 1) Hot asphalt mixture without using wire mesh layer; 2) Hot asphalt mixture with 20 mm Wire mesh layer placement from the top of the test specimen; 3) Hot asphalt mixture with 30 mm Wire mesh layer placement from the top of the test piece and; 4) Mix hot asphalt with 20 mm wire mesh layer placement from the bottom of the test specimen. The height of the test specimen is 60 mm [9].

Test equipment used is Marshall test equipment and Wheel tracking machine. Some parameters taken to make it easy to analyze data to get accurate results are the characteristics of Marshall and the rate of deformation[8].

II. THEORETICAL BASIS

1.1 Flexible Pavement

Flexible pavement is a pavement layer consisting of subgrade, subbase course, base course and surface course [8,10].

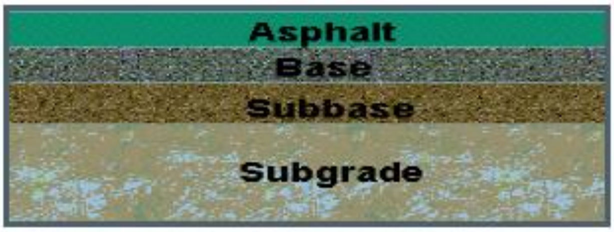

Figure 1: Flexible pavement component arrangement

2.2 Asphalt Concrete Coating

Asphalt concrete coating is a layer in the construction of the highway, which consists of a mixture of hard asphalt and aggregates that are graded continuously, mixed, spread and compacted in a hot condition at a certain temperature [8,10,11]. The aggregate material consists of a mixture of coarse aggregates, fine aggregates and well graded fillers mixed with asphalt penetration grade [10].

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2.3 Wire Mesh

Wiremesh is a reinforcement of the pembesian pattern that is often used in rigid Pavement [12,13]. In rigid Pavement, the use of Wire mesh is also used as a crack control and pumping control due to controlled stress and deflection values thereby increasing service index [13,14]

Wiremesh or so-called woven wire or woven iron is a series of woven iron so that it resembles iron nets which are commonly used for reinforcing concrete. The shape is in the form of iron boxes that each meeting is glued together by welding.

Figure 2: Wire mesh

2.4. Marshall Test

The Marshall test is an important step in determining the characteristics of an asphalt mixture. The Marshall parameters to determine the characteristics of asphalt mixtures are stability, durability, plasticity (flow), density, Marshall Quotient, cavities in the mixture, cavities in mineral aggregates, and cavities filled with asphalt. By using Marshall test equipment and analyzing the characteristics of Marshall, you will get an Optimum Asphalt Level [8].

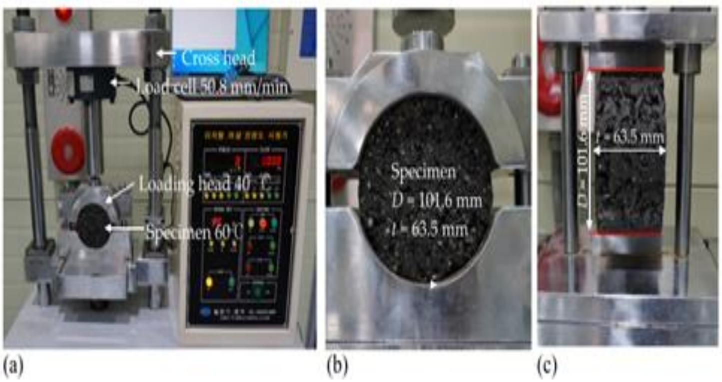

Figure 3: Marshall Test Equipment

The advantages of using the Marshall method are as follows [8] :

a. Easy to carry and adapted to other stability tools;
b. It is very simple and gives fairly thorough results and is considered a good method;
c. Can be used to check a number of mixes, especially sample mixes taken directly from the Asphalt Mixing Plant (AMP).

2.5 Wheel Tracking Machine

For testing the hot asphalt mixture due to load repetition in an effort to analyze the value of the deformation that occurs the Wheel tracking machine is used. This tool can detect phenomena and events that are experienced by asphalt mixture samples when experiencing load repetition due to the wheel drive [15].

The mold for the wheel tracking specimen is a plane consisting of a square with a length of 400 mm and a width of 300 mm and a height of 90 cm. The surface temperature of the specimen and the chamber in the test equipment is deliberately maintained at 60ºC to assess the dynamic stability of asphalt concrete at high temperatures when the concrete loses its adhesion and is resistant to external forces [16].

Figure 4: Mold Test Wheel Tracking Machine

Figure 5: Whell Tracking Machine

The test wheel, with a diameter of 200 mm, width 50 mm, and a rubber layer with a thickness of 15 mm, is moved forward and backward on the surface of the specimen at 42 cycles per minute, and the perpendicular load exerted by the test wheel to the specimen is maintained at 686 N. The speed and rate of specimen deformation are calculated using the following equation [15] :

$$RD = d60 - \frac{d45}{15} \quad \text{...1)}$$

RD = the rate of deformation (mm/minute),

d45 and d60 = represent the amount of deformation measured respectively at 45 and 60 minute.

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Test results from three samples are averaged to obtain accurate representative values for variables. Rutting on the highway can be explained in three levels [7]:

a. Low severity, depth < 25 mm;

To handle the low severity level, handling can usually be done with an overlay.

b. Moderate damage (medium severity), ie grooves depth of 25-75 mm;

To handle the level of medium severity handling by patching.

c. High severity, ie grooves depth > 75 mm.

Handling high severity requires heavy handling or reconstruction. Critical sidewalk conditions usually occur at temperatures above 50ºC or below 5°C, while at high temperatures, asphalt pavement will be vulnerable to plastic deformation caused by traffic loads.

III. RESULTS AND DISCUSSION

3.1 Optimum Asphalt Levels

The initial stage in research on hot asphalt mixtures is to determine the Optimum Asphalt Level. Marshall characteristic is an important thing needed in the analysis process to obtain optimum asphalt content values such as cavities in the mixture, asphalt filled cavities, aggregate filled cavities, stability, melting and Marshal Quetion. Based on the results of the evaluation of Marshall characteristics in testing using Marshall tools obtained an Optimum Asphalt Level of 5.75%.

3.2 Deformation speed analysis

The best deformation speed is taken based on the lowest speed value of the planned variation of the test specimen. The low deformation velocity value indicates the low level of damage to the surface layer in flexible pavement.

The specimens used in testing using the Wheel Tracking machine were made based on the optimum asphalt content value of 5.75% based on the results of the evaluation of Marshall characteristics. Based on the optimum bitumen content, test specimens are made with 4 types of wire mesh layer placement modeling as described in the following data analysis table for deformation speed.

Table 1: Data analysis of deformation speed

#	Number of Test Object	DATA ANALYSIS		INFORMATION
		RD	Comparison	
		mm/minute	%	
1	1	0,0282	52,6	
2	2	0,0134	0,0	RD = Deformation Speed
3	3	0,0409	67,3	
4	4	0,0268	50,2	

Note :
Type of test object
1 hot asphalt mixture without wire mesh layers;
2 hot asphalt mixture by laying 20 mm wire mesh layers from the surface of the test object;
3 hot asphalt mixture by laying 30 mm wire mesh layers from the surface of the test object;
4 hot asphalt mixture by laying 20 mm wire mesh layers from the bottom of the test object

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Based on the results of the research table, it was found that type 2 specimens, namely hot asphalt mixture with 20 mm wire mesh placement from the surface of specimens of 0.0134 mm/minute, had deformation velocity values that were smaller than the other 3 types of test specimens. If a comparison is made in the percentage of the 3 other types of test items, it is found that:

a. The hot asphalt mixture with 20 mm wire mesh layer placement from the surface of the test specimen (type 2) is 52.6% smaller than the hot asphalt mixture without the use of wire mesh layer (type 1)

b. The hot asphalt mixture with 20 mm wire mesh layer placement from the surface of the test specimen (type 2) is 67.3% smaller than the hot asphalt mixture with 30 mm wire mesh layer placement from the surface of the test object (type 3)

c. The hot asphalt mixture with 20 mm wire mesh layer placement from the surface of the test specimen (type 2) is 50.2% smaller than the hot asphalt mixture with 20 mm wire mesh layer placement from the base of the test object (type 4)

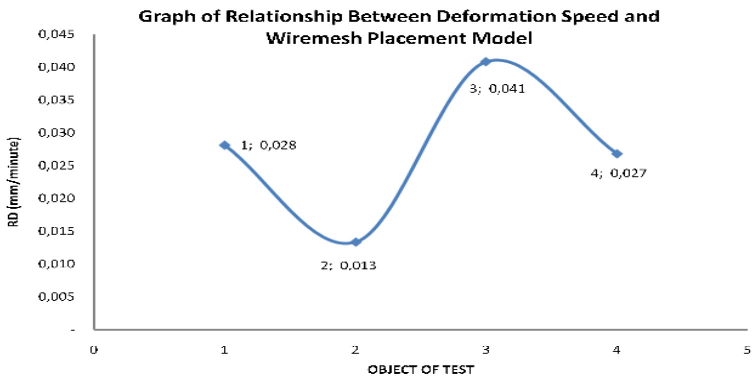

Figure 6: Relationship between deformation speed and wire mesh placement model

Based on the graph, it can be seen that the best deformation velocity is obtained in type 2 modeling, which is a mixture of hot asphalt with wire mesh layer placement 20 mm from the surface of the test object at 0.0134 mm/minute.

3.3 Relationship between Deformation and Trajectory

The results that connect the deformation value and the number of trajectories are needed to determine the phenomena that occur in hot asphalt mixtures with variations of 4 types of wire mesh layer placement as reinforcement. The following tables and graphs describe the maximum and minimum deformation values that occur due to load repetition.

Table 2: Relationship between deformation and trajectory

#	NUMBER OF TRAFFIC	DEFORMATION OF TEST OBJECT 1 (mm)	2 (mm)	3 (mm)	4 (mm)	INFORMATION
1	0	-	-	-	-	
2	200	0,532	0,495	1,242	0,857	
3	400	0,795	1,147	1,715	1,133	
4	600	1,008	1,257	2,132	1,441	
5	800	1,270	1,323	2,536	1,759	
6	946	1,451	1,380	2,896	1,981	
7	1000	1,530	1,427	2,985	2,054	
8	1261	1,874	1,580	3,509	2,384	
9	1915	2,867	1,988	5,237	3,394	
10	2500	3,627	2,194	6,507	4,159	

Note :
Type of test object
1 hot asphalt mixture without wire mesh layers (as a comparison standard);
2 hot asphalt mixture by laying 2 cm wire mesh layers from the surface of the test object;
3 hot asphalt mixture by laying 3 cm wire mesh layers from the surface of the test object;
4 hot asphalt mixture by laying 2 cm wire mesh layers from the bottom of the test object

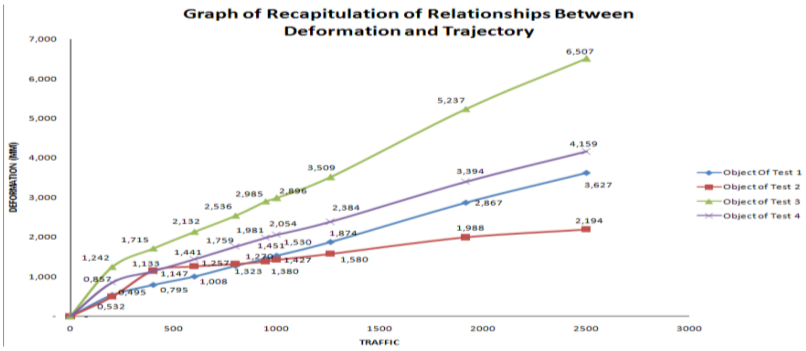

Figure 7: The relationship between deformation and the number of trajectories

Based on the graph and table above, it was found that the deepest deformation on the 2500th path which is 6.507 mm was found in type 3 modeling, namely a mixture of hot asphalt with a wire mesh layer placed 30 mm from the surface of the test specimen. The best model is obtained on a hot asphalt mixture with a wire mesh layer placed 20 mm from the surface of the test specimen which is 2,194 mm.

IV. CONCLUSIONS

Based on the results of research using Marshall test equipment and Wheel Tracking Machine, it can be concluded that several things include:

a. The Optimum Asphalt Level Value is 5.75%;

b. The best or lowest deformation speed is obtained on a hot asphalt mixture with a wire mesh layer placed 20 mm from the surface of the test object that is 0.0134 mm/minute

c. The percentage ratio of the best deformation speed on a hot asphalt mixture with a wire mesh layer placed 20 mm from the surface of the test specimen with a hot asphalt mixture without using a wire mesh layer is 52.6% lower

d. The best deformation on the 2500th passage was obtained on the AC-WC hot asphalt mixture with wire mesh placed 2 cm from the surface of the test specimen, 2.194 mm;

e. From the four types of modeling planned, it was found that the hot asphalt mixture with a wire mesh layer placed 20 mm from the surface of the test specimen is the best model to withstand the deformation velocity on the hot asphalt mixture

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