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Flexural Resistance Analysis on Hot Asphalt Mixtures with Wire Mesh Placement Modeling as Reinforcement

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Abstract. Flexural resistance is the ability of a specimen to withstand force in two pedestals with vertical axis until it is broken. Flexible pavement is a type of pavement which is very dependent with pavement course underneath. The dependency of flexible pavement in both base course and subgrade makes this pavement difficult to apply in unstable soil. Using wire mesh course as reinforcement is considerably able to raise the flexural resistance. This study is aimed to analyze flexural resistance value in hot mix by using wire mesh course as reinforcement. The study is conducted by applying experimental method with designing four types of wire mesh laying models in hot mix using three points flexural test equipment. Based on the study result, it is found that hot mix with wire mesh laying 30 mm from specimen surface is the best model type with 291,85 KN flexural resistance value with 8 mm of deflection depth. In this laying, it can be concluded that wire mesh course can raise up the flexural resistance up to 35,41% compared to the hot mix without wire mesh course.

Introduction

Generally, road constructions in Indonesia use hot mix asphalt as the cover course of pavement. Using asphalt as the main ingredient in road pavement construction is the classification of flexible [1, 2, 3, 4, 5, 6]. Flexible pavement has several courses ; surface, base course and subbase course which are located on the subgrade [3, 5, 7, 8]. Flexible pavement is very dependent on the base course and the subgrade which cause some weaknesses such as damage that can decrease the age of plan [1, 2, 3, 5].

Due to the dependency of flexible pavement strength to base course and subgrade, this type of pavement is not recommended to be applied to the unstable soil. This causes the limitation of the flexible pavement whereas the flexible pavement has many other advantages [3, 5, 7, 8]. To overcome this problem, it is necessary to design the flexible pavement that can hold its own load to reduce its dependency to the base course and the subgrade [3, 5]. The design of hot mix asphalt using wire mesh is considerably able to solve the problem and it can be proven with flexural resistance analysis.

Flexural resistance is a treatment that is frequently used to rigid pavement. The flexural resistance of concrete is an ability of concrete block located in two pedestals to withstand force with vertical axis of given specimen and stated in Megapascal (Mpa) force per unit area [3, 5]

In rigid pavement, Wire mesh is used as crack and pumping control caused by controlled stress and deflection values that increase the service index [10, 11]. Wire mesh rigidity is also considerably capable to increase the value of elasticity modulus.

Reinforcement usage is considerably able to make flexural resistance less dependent on the base course and the subgrade so it can be applied on the unstable soil [3, 5, 9, 11, 12]. High modulus of elasticity in a pavement will cause the structure strength stays in its own pavement [1, 9, 13, 14,

15]. Several previous studies related to the method used in crack control and holding tensile force used the box pattern contained in a pavement [1, 16, 17, 18].

In this study, the examination and analysis is done by modelling the placement of wire mesh 20 mm from the base of the specimen, in the center or 30 mm from the surface of the specimen and 20 mm from the surface of the specimen with the specimen height is 60 mm [18, 19, 20, 21, 22, 23]. The aim of this study is to analyze the flexural resistance owned by hot mix asphalt with wire mesh course as the reinforcement to reduce the dependency to the flexible pavement in the base course and the subgrade.

Literature Review and Theory

Flexible Pavement. The flexible pavement is a pavement course contained of subgrade, subbase course, base course and surface [3, 5, 7, 8, 24]. Hot mix asphalt is a course in road construction consisted of the mixture of hard asphalt with aggregate that graded continuously, then both of them are mixed, spread out and compacted while it is in hot condition at the certain temperature [3, 5, 7, 8, 24, 25]. The aggregate material itself contained a mixture of coarse and fine aggregates,as well as well graded filler mixed with asphalt [3, 5, 7, 8, 24].

In asphalt mixture, asphalt functions as the binder among the aggregate particles, while the aggregate functions as the reinforcement. The mechanical characteristics of asphalt in hot mix is obtained from the friction and the cohesion of its forming materials [3, 5, 7, 8].

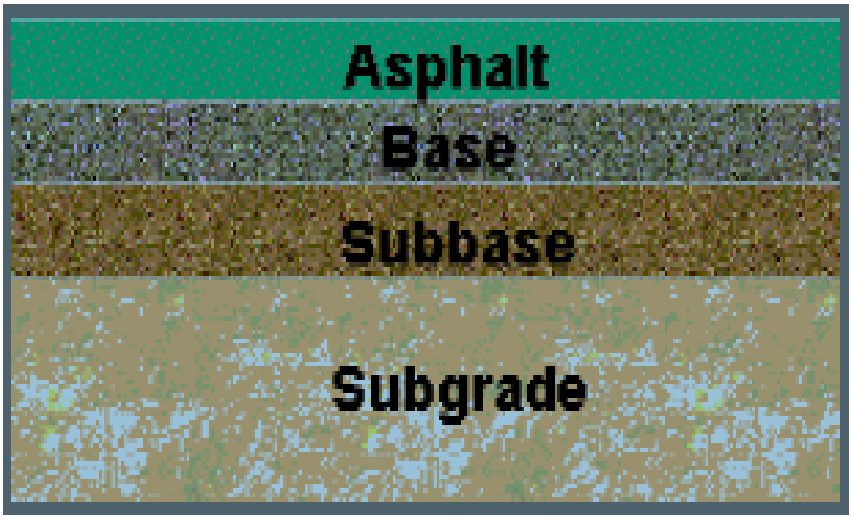

Fig. 1 Composition of flexible pavement components

Wire Mesh. Wire mesh is a reinforcement pattern which is frequently used in rigid pavement [3, 5, 8, 9, 26]. In rigid pavement, Wire mesh is also applied to control the crack and pumping caused by controlled stress and deflection values which increase the service index [2, 9, 10, 27].

Wire mesh which is commonly called as woven wire/iron is the iron chain woven like the iron net which is usually used to reinforce roof concrete. Its shape forms as iron boxes and welded to connect one box to another.

Fig. 2 Wire mesh

Marshall Test. Marshall test is an important step to determine the characteristic of asphalt mix. There are several parameters used in this test; stability, durability, flow, density, Marshall Quotient, cavity in mixture and aggregates as well as filled asphalt cavity [5, 6, 8, 12, 13].

By using Marshall test and analyzing Marshall characteristics, the optimum Asphalt content can be obtained.

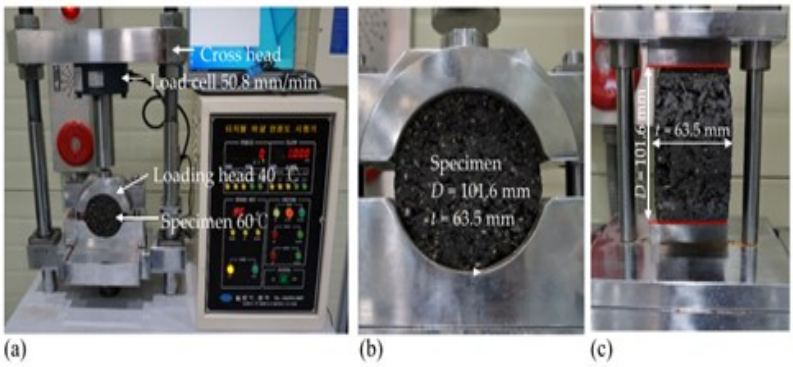

Fig. 3 Marshall test equipment

Three Point Flexural Test. Three points flexural test is carried out in line with the standard to measure the flexural performance of asphalt concrete at 10°C, where at this temperature the asphalt mix will susceptibly crack [28]. The loading rate is controlled at 50 mm/minute.

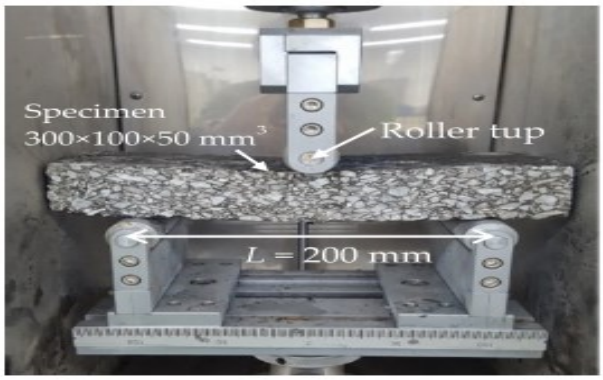

Fig. 4 Three point flexural test equipment [16]

Research Methodology

This research is conducted by applying an experimental method using wire mesh as reinforcement material in local loading terms. The wire mesh is used as the object for this research because it is easy to find as well as affordable so it will be easily applied in road pavement construction projects. [5, 9, 16, 26, 29, 30, 31, 32].

The specimen used for this research is the mixture of hot mix asphalt and the mixture of aggregate and asphalt together with wire mesh. The specification of the wire mesh used here has 4 mm diameter with the hole size is 150 mm. The total specimens are 32 consist of 24 specimens for gaining the optimum asphalt content with Marshall characteristic analysis and 8 specimens to analyze the flexural resistance value of hot mix with wire mesh course as the reinforcement.

Four models of wire mesh positioning are carried out to the specimens in order to to analyze the flexural resistance value using the three points flexural test, they are :

1. Hot mix asphalt without wire mesh as the comparison standard
2. Hot mix asphalt by placing wire mesh 20 mm from the surface of the specimen
3. Hot mix asphalt by placing wire mesh 30 mm from the surface of the specimen
4. Hot mix asphalt by placing wire mesh 20 mm from the base of the specimen

The testing tool used in this experiment is Marshall Test to obtain the Optimum Asphalt Content while the three points of flexural test is used to analyze the flexural resistance [18, 19, 29, 30, 33, 34]. Several parameters are taken in order to ease the data analysis process and to gain the expected result which are Marshall characteristic and flexible pavement performance ; maximum load value and deflection or deformation [6, 8, 12, 18, 22].

Results and Discussion

The Optimum Asphalt Content. The first step of hot mix asphalt research is determining the Optimum Asphalt Content (OAC). After the physical examination of the aggregate and the asphalt, it is then continued by creating the specimens to analyze the Marshall characteristic.

Marshall Characteristics are the important things needed in analyzing process to obtain the OAC value which covers cavities, filled aggregate cavities, stabilities, melting and Marshal Quetion. Based on Marshall characteristic evaluation in specimen examination using Marshall equipment, it is found that the value of OAC is 5,75%.

Correlation Between Loading and Wire Mesh Placement Models. The analysis of correlation between loading and wire mesh placement models obtained from hot mix asphalt is carried out by using three points flexural test. The specimen used is the mixture of hot mix asphalt in OAC achieved from Marshall characteristic analysis which is 5,75%.

The specimens are designed with four types of M4 wire mesh placement in hot mix asphalt. The analysis result is displayed in table 1.

Table 1 Flexural testing results

Number Of The Specimen	Load (P)		Deflection	Stress	Strain	Modulus Of Elasticity	Poison Ratio
	KN	N	Mm	Mpa		Mpa	
1	188,5	188.500	9,5	78,54	0,038	2.066,89	0,15-0,45
2	197,7	197.700	9	82,38	0,036	2.288,19	0,15-0,45
3	291,85	291.850	8	121,60	0,032	3.800,13	0,15-0,45
4	251,3	251.300	8	104,71	0,032	3.272,14	0,15-0,45

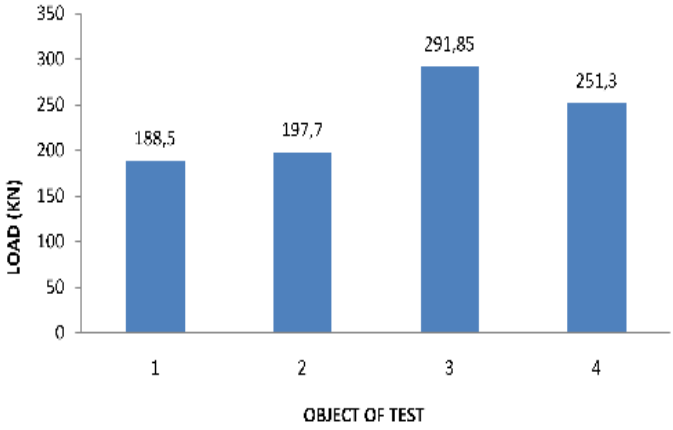

Fig. 5 Correlation between loading and model of wire mesh placement

Based on the research result, it is found that the highest load that can be withstood by the hot mix asphalt is at the specimen type 3 which is the mixture of hot mix asphalt by placing wire mesh 30 mm from the surface of the specimen, 291,85 KN. The deflection amount is between 8 – 9,5 mm. in detail can be described as follows :

a. The mixture of hot mix asphalt by placing wire mesh 30 mm from the surface of the specimen (type no.3) which is 291.85 KN is a test object capable of withstanding the highest load compared to the other three specimens with the amount of deflection is 8 mm.
b. The mixture of hot mix asphalt by placing wire mesh 20 mm from the base of the specimen (type no.4) which is 251.3 KN has the ability to withstand a load higher than the mixture of hot mix asphalt by placing wire mesh 20 mm from the surface of the specimen (type no.2) and the mixture of hot mix asphalt without wire mesh course (type no.1) with the amount of deflection is 8 mm.
c. The mixture of hot mix asphalt by placing wire mesh 20 mm from the surface of the specimen (type no.2) which is 197.7 KN has a greater ability to withstand loads when compared to the mixture of hot mix asphalt without wire mesh course (type no.1) with the amount of deflection is 9 mm.
d. The mixture of hot mix asphalt without wire mesh course (type no.1) which is 188.5 KN is an asphalt mixture with the ability to withstand the weaker or smaller load than hot asphalt mixture using wire mesh layers with the amount of deflection is 9.5 mm.

Percentage Analysis of Maximum Loading Comparison. The three points flexure test equipment provides data in obtaining maximum load from each of wire mesh course placement type. The percentage analysis of maximum loading compared to wire mesh course placement types can be seen in the table 2.

Table 2 Percentage analysis of maximum loading

#	Number Of The Specimen	Maximum Load KN	Maksimum Load Comparizon %
1	1	188,5	35,41
2	2	197,7	32,26
3	3	291,85	0
4	4	251,3	13,89

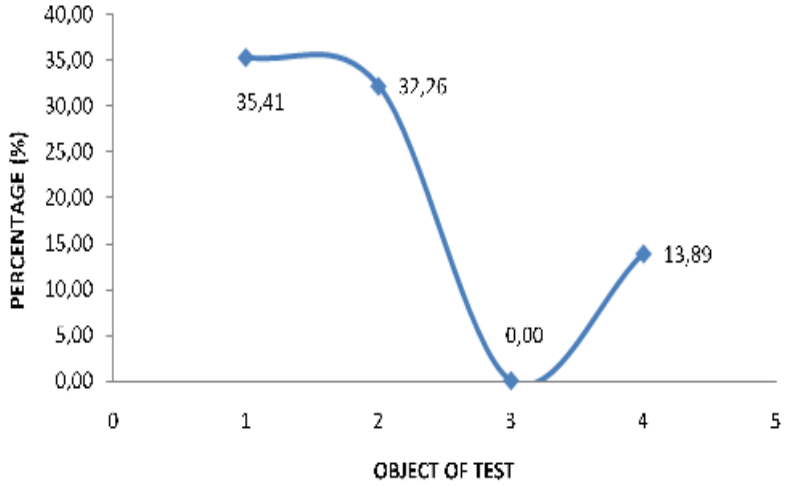

Fig. 6 Correlation between wire mesh placement models and percentage analysis

Based on the graph and table above, it is obtained the comparison percentage of maximum loading with the other types of placement at maximum load 291,85 KN in the mixture of hot mix asphalt with wire mesh course placed 30 mm from the surface of the specimen. If the comparison in percentage to three types of other specimens is taken, it is found that :

a. The mixture of hot mix asphalt by placing wire mesh 30 mm from the surface of the specimen (type no.3) is bigger 35,41% than the mixture of hot mix asphalt without using wire mesh course (type no.1) which is 188,5 KN
b. The mixture of hot mix asphalt by placing wire mesh 30 mm from the surface of the specimen (type no.3) is bigger 32,26% than the mixture of hot mix asphalt by placing wire mesh 20 mm from the surface of the specimen (type no.2) which is 197,7 KN
c. The mixture of hot mix asphalt by placing wire mesh 30 mm from the surface of the specimen (type no.3) is bigger 13,89% than the mixture of hit mix asphalt by placing wire mesh 20 mm from the base of the specimen (type no.4) which is 251,3 KN

Conclusions

According to Marshall Test equipment and Three points flexure test, it can be concluded that :

a. The use of wire mesh course in hot mix asphalt can increase the flexural resistance in hot mix asphalt.
b. The highest load that can be withstood as the value of flexural resistance obtained in the mixture of hot mix asphalt with the wire mesh course placed 30 mm from the surface of the specimen, which is 291,85 KN with the amount of deflection is 8 mm.
c. The amount of deflection is between 8 – 9,5 mm
d. The comparison percentage of highest load in hot mix asphalt with wire mesh course place 30 mm from the surface of the specimen with the mixture of hot mix asphalt without wire mesh is lower 35,41%
e. From the four types of designing models, it is found that the mixture of hot mix asphalt with wire mesh course placed 30 mm from the surface of the specimen is the best model for the highest flexural resistance value.

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