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PERMEABILITY AND DURABILITY OF SEMI-FLEXIBLE PAVEMENT WITH WASTE TIRE RUBBER AND NATURAL ZEOLITE ADDITION

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ABSTRACT

The durability of pavement is caused by the problem of surface drainage in every part of the highway, which may be different and requires consideration after special care depending on the location conditions. Good drainage is generally achieved by providing material gradations that are in accordance with adequate permeability with structural adequacy that depends on site conditions by taking into account the intensity of rain in the area. The purpose of this study was to study the permeability of falling head permeability (FHP) methods and the durability of the Marshall method from semi-flexible hardness using used tire rubber and natural zeolite as a substitute for asphalt and cement. The mix design of porous asphalt is started with determination of optimum asphalt proportion with open graded aggregat as spesified in *Australian Asphalt Pavement Assosiation* (*AAPA*) 2004.. The asphalt was then replaced with 3%, 4% and 5% waste tire rubber and the Marshall Test was conducted. The cement mortar with 0 %, 5 %, 10 %, 15 % and 20 % natural ziolite was injected to porous asplalt specimens. Permeability tests and durability are conditioned according to ASTM C670-91a at 14 days of specimen age. The test results showed that the highest permeability value was obtained at 0.0529 cm / second and the highest durability was 91.45% in 15% of Aceh's natural zeolites. The value of durability is much higher than the required specifications of 75%.

KEY WORDS: waste tire rubber, natural ziolite, permeability, durability

INTRODUCTION

1.1. Background

The durability of pavement is caused by the problem of surface drainage in every part of the highway may be different and requires consideration after special care depends on the location conditions. Good drainage is generally achieved using material gradations that are in accordance with adequate permeability with structural adequacy that depends on site conditions by taking into account the intensity of rain in the area [1]. The use of the right type of pavement is one solution to the problem of pavement surface drainage. Semi-flexible pavement (PSF) made with a mixture of open graded asphalt matrix (void ratio of 20-30%) and filled with selected cement grout [2]. PSF quality is influenced by many factors, including the properties of aggregate properties, gradation, mixture stiffness, quality and content of cement mortar, and drainage system. The period of pavement service will increase if the appropriate asphalt binder is adopted [3]. The addition of waste tire recycling (WTR) to the asphalt binder base can improve bitumen binding properties, such as reducing construction and maintenance costs, improving resistance to permanent deformation, reducing fatigue damage and potential thermal cracks, reducing the thickness of pavement structures and reducing the possibility of cracking [4]. Permeability values are directly proportional to VIM and inversely proportional to the value of density and stability [5]. Permeability which was carried out by falling head permeability (FHP) method and resulted in a permeability of 1.61x10-3 m / s even can be applied to macadam grouted [6]. The use of zeolite on concrete/mortar can improve its compressive strength and durability [7].

Based on the above description, research is required to develop PSF by modifying asphalt with waste tire rubber material and modifying cement with Aceh's natural zeolite as mortar. This research was conducted to find out the compressive strength of PSF mixture due to substitution of waste tire rubber on asphalt and natural zeolite substitution on cement as mortar material with a series of testing in the laboratory.

1.2. Purpose

The purpose of this study was to study the permeability using falling head permeability (FHP) method and the durability of the Marshall method from semi-flexible hardness using used tire rubber and natural zeolite as a substitute for 60/70 asphalt penetration and cement mortar with experimental methods. In addition, to determine the optimal proportion of used tire rubber and

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zeolite as PSF substitution materials to obtain maximum permeability and durability.

LITERATURE REVIEW

2. Materials and Method

2.1 Materials

Open graded split originated from river stone located in North Aceh is used as fine and coarse aggregate. The properties of fine and coarse aggregate are shown in Table 1 and 2, respectively. The aggregate gradation is shown in Figure 1 which is satisfied the requirement of Australian Asphalt Pavement Assosiation (AAPA) 2004 Standard [8]. Asphalt as a binder used in this study is penetration asphalt penetration 60/70 produced by PT. Pertamina. While the cement used in this study is Portland type II cement produced by PT. Semen Andalas Indonesia. The substitution materials are grated waste tire rubber and natural zeolite. The grated waste tire rubber is sieved to pass no.50 sieve before it is used in this study. The natural zeolite originated from Peukan Bada Aceh Besar District of Aceh Province is used. Natural zeolite is grinded to pass no. 200 sieve and chemically activated using chloride acid (HCl). After chemically activated, the natural zeolite is purified by Aqua D'Mineral.

Table 1. Fine aggregate properties

No.	Type of test	Test Method	Result	Spec.	Unit
1	Spec. gravity	SNI 03-1970-1990		Min. 2,5	gr/cm
	Bulk		2,521		
	SSD		500		
	Apparent		2,589		
2	Absorption	SNI 03-1969-1990	1,890	Max. 3	%

Table 2. Coarse aggregate properties

No.	Type of test	Test Method	Result	Spec.	Unit
1	Spec. gravity	SNI 03-1970-1990		Min. 2,5	gr/cm
	Bulk		2,340		
	SSD		500		
	Apparent		2,467		
2	Absorption	SNI 03-1969-1990	1,937	Max. 3	%

2.2 Experimental program

The tests in this study are based on Bina Marga Specification 2010 for hot mix [9] using open graded aggregate as specified in AAPA Specification 2004. Mix proportion of porous asphalt mixture in based on Marshall method to obtain Optimum Asphalt Content (OAC). After OAC was obtained, the specimens are prepared with 3 variations of waste tire rubber as asphalt replacement. The content of waste tire rubber used are 3 %, 4 % and 5 % of OAC.

The specimens then put in room temperature for 24 hours. After 24 hours in room temperature, the specimens were injected the mortar. The proportion of mortar is 1 cement : 2 sands by volume. The water used in mortar is 0,4 of cement weight. A natural zeolite is used for cement replacement. Four variations of zeolite content, which are 0 %, 5 %, 15 % and 25 % of cement weight are used. Before injected in the specimens, the viscous test of mortar was performed. To inject the mortar in the specimens, the specimen is inserted in the tube, then mortar was filled on the tube and vibrated using the table vibrator for 10 seconds. Compression test using a 200 kN capacity strength test apparatus was conducted on the specimens at the age of 14 days at room temperature.

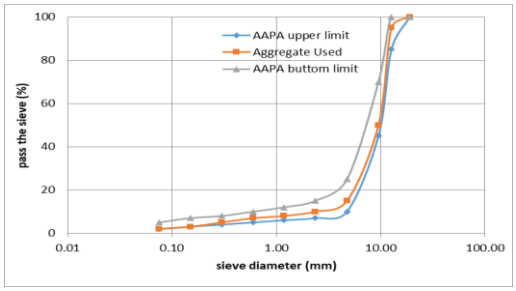

Figure 1. Gradation of aggregate

DISCUSSION

3. Result and analysis

3.1 Marshall test result for determination of OAC

Based on Marshall Test the stability, flow, and Voids in The Mix (VIM) were obtained as shown in Table 3 below:

Table 3. Marshall Test Result for determination of OAC

Parameter	AAPA Spec. 2004	Asphalt Content 3%	3.50%	4%	4.50%	5%
Stability (kg)	Min. 500	503	512	470	362	356
Flow (mm)	2 - 6	3.97	5.6	4	5.78	5.53
VIM (%)	18 - 25	24.95	26.7	22.64	18.43	13.88

Based on Table 3, it is found that optimum asphalt content is 3%. Therefore for the following investigation,

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the asphalt content used is 3 %.

3.2 Permeability and durability value of SPF mixes
The based on the testing permeabiliti and durability of semi flexible pavement for all variation of waste tire rubber and zeolite content is shown in Table 4. Based on the results in Table 3.2 the compression test results of PSF mixture showed that the substitution of used waste tire rubber in asphalt and substitution of Aceh natural zeolite in mortar cement can increase permeability and durability.

Table 4. Test results of permeability and durability on any variations of with waste tire rubber and zeolites

	Natural Zeolite (%)	Permeabilitas (cm/dtk)	Durabilitas (%)
Waste Tire Rubber 5%	0	0,004163	79,57
	5	0,0048	90,60
	15	0,004888	91,45
	25	0,00529	79,21

Based on the results in the table.4 above that the substitution of used tire powder and zeolite on asphalt and mortar cement can increase the value of permeability and durability of PSF.

3.3 Discussion on Marshall Test Results for the determination of OAC
Stability is an important factor to measure the quality of the porous asphalt mixture in the traffic load, the higher the stability value indicates the pavement the higher the stiffness value, but at certain limits there is still flexibility that is the value of flow. Void values in the mix (VIM) is a requirement that needs to be met that is about 20% -30%, cavity level is associated with the volume of mortar filled so that it affects PSF mixed permeability and durability. Of these three important parameters all meet the requirements of AAPA (2004) so that porous asphalt pavement can be used.

3.4 Discussion on permeability and durability Results
The PSF mixed strength test results that the mixture with the substitution of waste tire rubber in hot asphalt and natural zeolite substitution on mortar cement has increased the value of permeability and durability. Increasing the permeability value of the PSF mixture occurs with increasing zeolite variation. While the value of durability increases up to 15% zeolite, after that there is a decrease. The effect of permeability value of PSF mixture on variations of waste tire rubber in hot asphalt and zeolite on cement as mortar material can be seen in Figure 2.

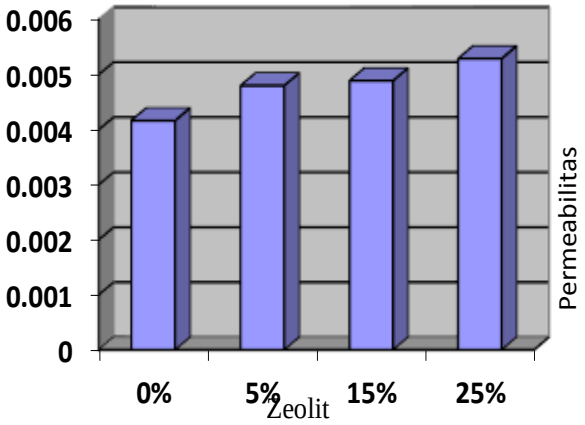

Figure 2. The relationship between zeolite levels and permeability in the 5% tire rubber waste

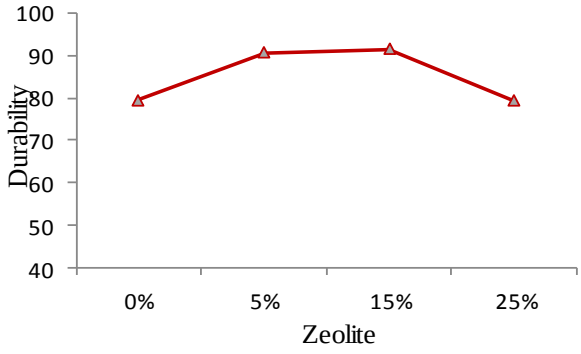

Figure 3. The relationship between zeolite levels and durability in the 5% tire rubber waste

Based on the picture above that the PSF mixture is substituted with used tire powder and zeolite as an asphalt and mortar cement substitution material that permeability and durability values have increased significantly. Increased permeability value and maximum PSF durability were obtained at 5% used tire powder and 15-25% zeolite. The increase in permeability and durability of the FSP along with the increase in substitution of used tire powder in hot asphalt causes the viscosity value of asphalt to be high, and affects the increase in VIM value. The VIM value in the mixture is needed to provide enough space for compaction due to traffic loads and the influence of temperature, besides that it needs to be a medium of permeability to drain rainwater. While the effect of zeolite substitution in mortar cement as macadam grout material can increase the value of durability up to 15%, this is because Aceh's natural zeolite contains relatively high silica (SiO2) and Alumina (Al2O3), so it can increase the value of cement mortar cohesion and can increase PSF stability which ultimately causes the value of durability to increase as well.

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CONCLUTION

a. From the results of the research and analysis that has been carried out, the following conclusions can be drawn:
b. Substitution of used tire powder in hot asphalt can increase the cavity content in the asphalt mixture, so that it can affect the permeability value and durability of the PSF mixture.
c. Aceh natural zeolite substitution in mortar cement as macadam grout material can increase the durability value of the PSF mixture.
d. Composition of used tire powder as hot asphalt substitution material which produces the highest durability in this study is 5%.
e. The composition of zeolite as a substitute for mortar cement which results in permeability and durability of PSF is 15% of activated natural zeolite in Aceh.

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