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The influence of the using waste tire rubber and natural ziolite as Asphalt and Cement replacements to compressive strength of Semi-Flexible Pavement

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Abstract. The objective of this research is to study the compressive strength of semi-flexible pavement by using waste tire rubber and natural zeolite as asphalt and cement replacements. The mix design of porous asphalt is started with a determination of optimum asphalt proportion with open-graded aggregate as specified in *Australian Asphalt Pavement Association* (*AAPA*) 2004. The asphalt was then replaced by 3 %, 4 % and 5 % of waste tire rubber and the Marshall test were conducted. The cement mortar with 0 %, 5 %, 10 %, 15 % and 20 % natural zeolite was injected to porous asphalt specimens. The compressive strength test was conducted based on ASTM C670-91a at the age of the specimens of 14 days. The test results showed that the higher compressive strength is reached at the 15 % natural zeolite and 5 % waste tire rubber, which is 15,43 MPa.

1. Introduction

Semi-flexible pavement (SFP) is a combination of two types of rigid pavement with flexible pavement that has several advantages [1]. SFP is made with a mixture of open-graded asphalt matrix (20-30% void ratio) and filling it with selected cement grout [2]. Mortality percentage of 80% of total voids with 3% asphalt content is the optimum composition in the semi-flexible mixture [3]. The use of natural zeolite in the asphalt concrete binder coarse (AC-BC) mixture as a filler can improve the stability of the soaking conditions in the ash of the stone [4].

Furthermore, rutting can be reduced if the asphalt stiffness of hot mixture increases at high temperatures. The service life of the pavement will increase if the appropriate asphalt binder modifier is adopted [5]. The additive of waste tire recycling (WTR) to the base of the asphalt binder can improve the asphalt binder properties, such as reducing construction and maintenance costs, improving the resistance to permanent deformation, reducing fatigue damage and potential thermal cracking, reducing pavement thickness and reducing the possibility of cracking reflective [6].

Indonesia is one of the countries with the most significant natural zeolite reserve in the world and spread almost in every region especially Sumatra and Java. Natural zeolite as an added material is in addition to competitive regarding cost when compared with synthetic zeolites that are only produced abroad, also due to natural zeolite deposits in Indonesia of 400 million tons.

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 the substitution of waste tire rubber on asphalt and natural zeolite substitution on cement as mortar material with a series of testing in the laboratory.

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The purpose of modified polymer asphalt uses a technology of warm asphalt mixture with natural zeolite additive materials. This study was conducted to determine the resistance of deformation due to natural zeolite additives on a warm asphalt mixture using asphalt modified series of testing in the laboratory. The use of zeolite on concrete/mortar can improve its compressive strength and durability [7].

This study aims to find out and evaluate the effect of substitution of used waste tire rubber on asphalt and substitution of Aceh natural zeolite on mortar as a mixture of PSF. In detail the purpose of this study are as follows:

a. To obtain the composition of PSF mixture substance using waste tire rubber and Aceh natural zeolite.
b. To analyze the compressive strength of PSF mixture using 60/70 penetration asphalt and Aceh natural zeolite as cement replacement.

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 Association (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	Specification	Unit
1	Specific 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	Specification	Unit
1	Specific 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 is 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 is 3 %, 4 % and 5 % of OAC.

The specimens then put in room temperature for 24 hours. After 24 hours in room temperature, the specimens have 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.

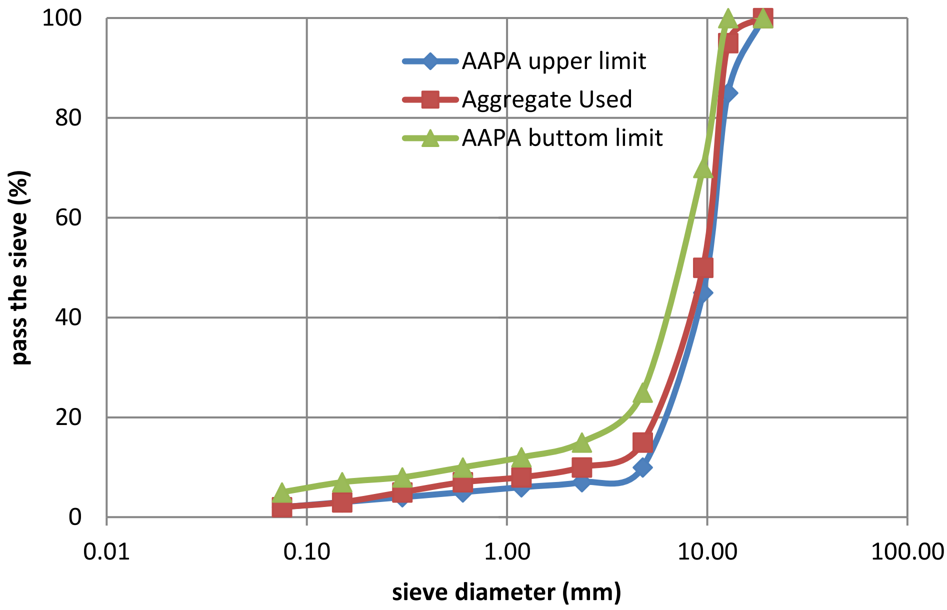

Figure 1. Gradation of aggregate

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 Specification 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, the asphalt content used is 3 %.

3.2 Compressive Strength

The compressive strength 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 could increase compressive strength at certain limits, after which the value of compressive strength decreased.

Table 4. Test results of compressive strength on any variations of with waste tire rubber and zeolites

No	Zeolite (%)	Waste Tire Rubber (%)	Compressive Strength (MPa)
		3	12.53
1	0	4	11.57
		5	8.1
		3	12.53
2	5	4	14.08
		5	13.5
		3	12.53
3	15	4	14.46
		5	15.43
		3	7.13
4	25%	4	6.36
		5	8.1

3.3 Discussion on Marshall Test Results for the determination of OAC

Stability is an essential 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 compressive strength. Of these three important parameters all meet the requirements of AAPA (2004) so that porous asphalt pavement can be used.

3.4 Discussion on Compressive Strength 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 compressive strength. The increase of compressive strength value of PSF mixture obtained varies considerably, in zeolite substitution with 0% variation and used tire substitution 3%, 4%, 5% value of compressive strength decreases. While on the variation of 15% zeolite with the variation of tire used 5% mixed PSF increased value of maximum compressive strength and after that happened decrease. The effect of compressive strength 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 3, and Figure 4.

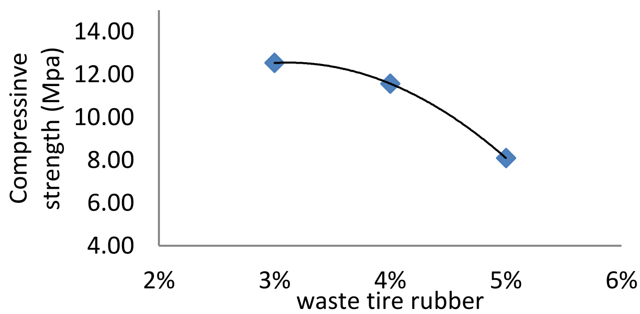

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Figure 2. Relation of compressive strength content to waste tire rubber (zeolite 0%)

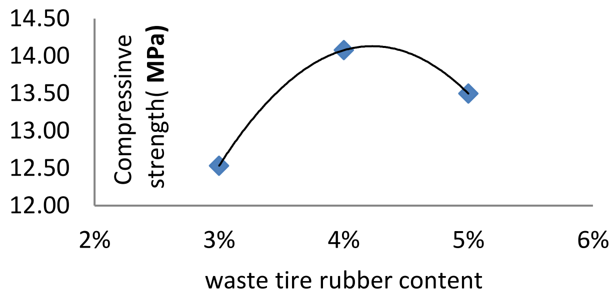

Figure 3. Relation of compressive strength content to used tire rubber (zeolite 5%)

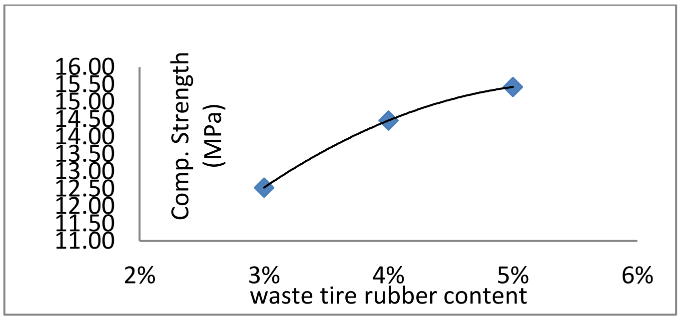

Figure 4. Relation of compressive strength content to used tire rubber (zeolite 25%)

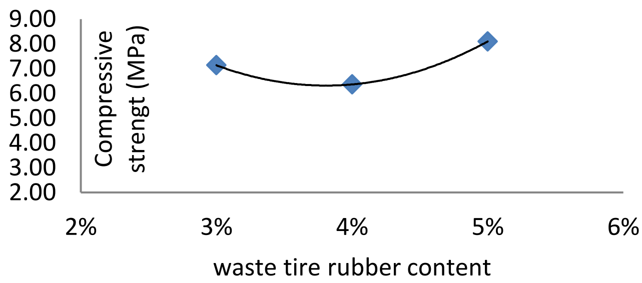

Figure 5. Relation of compressive strength content to used tire rubber (zeolite 25%)

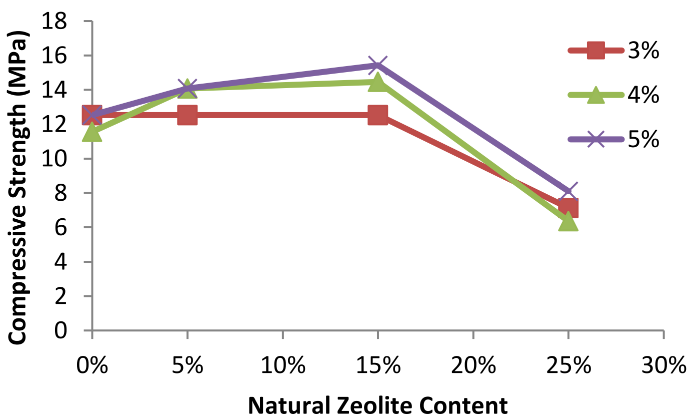

Figure 6. Relationship of compressive strength values to zeolite content

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4. Conclusions

a. The substitution of the used tire powder on the oil asphalt in the porous asphalt mixture can increase the cavity level in the mixture, thereby affecting the compressive strength value of the PSF mixture.

b. Substitution of Aceh's natural zeolite on cement as mortar can increase the strength of the compressive strength value of Semi-Flexible Pavement mix.

c. The maximum compressive strength value of 15.43 MPa was obtained at the level of 5% of used tires and 15% of Aceh's natural zeolite, after a decrease

5. References

[1] Zoorob S E, Hassan K E, Setyawan A 2002 Effect of cementitious grout on the properties of semi-flexible bituminous pavement, *Proceedings of the Fourth European Symposium on Performance of Bituminous and Hydraulic Materials in Pavements,* Nottingham, United Kingdom, 11-12 April, pp 105-112

[2] Nadiah M H, Karim, M R, Mahmud, H B Koting S 2014 *Adv. Mater. Sci. Eng.* **2014** 529305

[3] Setyawan A 2013 Asessing the Compressive Strength Properties of Semi-Flexible Pavements, *Proceeding The 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering Asessing Procedia Engineering* pp. 863-874

[4] Saleh A and Suparma L B 2015 Perancangan Laboratorium Pada Campuran Asphalt Concrete-Binder Course (AC-BC) Dengan Menggunakan Aspal Pen 60 / 70 Dan Zeolit Alam Sebagai Filler, *Annual Civil Engineering Seminar 2015*, Pekanbaru, pp 978-979

[5] Casey, Donnchadh, McNally, Amanda Gilchrist M D 2014 Resources Conservation and Recycling **52** 1167-1174

[6] Ge D, Yan K, You Z, Xu H 2015 *Constr. Build. Mater.* **126** 66–76

[7] Hasan M, Husin S and Nursaniah C 2016 *Key Engineering Materials* **711** 302-309

[8] Anonim, 2004, Open Graded asphalt Design Guide (Australian Asphalt Pavement Association), Australia

[9] Kementerian Pekerjaan Umum Direktorat Jenderal Bina Marga 2010 *General Specification Division 6 Asphalt Pavement* pp 6.1 – 6.5 (in Bahasa Indonesia)