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Research paper

The Effect of Adding Waste Tire Rubber Powder on Asphalt Concrete of Highway Density

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Abstract

Diseases in plants are something that can happen to many plants either caused by pests or other factors, the disease in plants can be detected based on the symptoms that appear on the plant before spreading to all plants, to recognize the symptoms and types of diseases contained in plants require plant experts or also by applying expert systems with expert knowledge base applied to the system by using certain methods such as certainty factor method. Expected results with the availability of this expert system to the user can help many users to detect diseases in plants.

Keywords: *Expert System, Certainty Factor, Plant Diseases*

1. Introduction

The construction industry has been burgeoning from year to year. The development of the construction industry has also made the highway construction industry increased rapidly. In this case, the quality of road construction that is asphalted pavement in serving the traffic flow is the result of interactive influence of the quality of planning that includes the fulfilment of quality materials that meet the specifications and execution of appropriate road construction work[1].
The wide use of hot mixed asphalt concrete was caused from materials that are generally easy to obtain, but the demands of quality asphalt pavement in serving the intensity of the higher traffic load and the extreme environmental impacts require the engineers in the field of road pavement usually add additional material (additives) and substitute material (substitute) into hot mixed asphalt concrete[2].
Nowadays, the use of additives and substitutes into hot mixed asphalt concrete has been widely used for several reasons e.g. if high-stick asphalt is needed, then the asphalt will be added with a high-stick polymer such as a plastomer or if the desired asphalt that can withstand varying temperatures then the asphalt will be added with polymer[1], [3], [4]. Plastomers are able to withstand varying temperatures or at a location where roads are built, there is difficulty in obtaining filler material, one of the solutions is by using a filler replacement material on hot mixed asphalt concrete[5].
On the other hand, many wasted materials or wastes can be easily found around environment which makes environmental pollution, but such wasted materials are potentials to be used as a material in hot mixed asphalt concrete which is believed to enhance performance such as stability and durability. One of the materials is used rubber powder tire. The used rubber powder tire consists of Carbon (32,19%); Silica (1.64%); Sulphur (2.13%); Rubber / Latex (64.04%).

Research on utilization of used tires as an additive material (asphalt) has previously been researched by the US Department of Transportation Federal Highway Administration in America since 1986[6].
The finding of the research showed that the utilization of used scrap tires was able to reduce damage to the flexible pavement caused by weather and traffic factors [7].

Research Objectives

The objective of the hot mix asphalt concrete research with the mixture of used rubber tire powder is to produce a good quality with maximum strength with the design of the used rubber powder mixture of 5%, 10%, 15% and 20%. Several objectives are as follow:

a. Determining sufficient asphalt to ensure density.
b. Knowing the maximum density of asphalt mixture produced by using rubber tire powder.
c. Knowing the stability value of the pavement produced by adding rubber tire powder.
d. Knowing what percentage of powdered rubber tire content is needed if it is feasible to use in hot mixed asphalt concrete or hot mix.
e. Limiting the cavity level to bind the permeability of the material against the entry of air and moisture that is very dangerous into the pavement.
f. Knowing the value of melting of hot mixed asphalt concrete by using used rubber tire powder.
g. Ensuring ease of workmanship sufficient to provide ease and efficiency in the spread without any segregation and without sacrificing stability and performance.

2. Methodology

Materials

The materials used are:

Coarse Aggregate	: Stone Break Machine of GMM Ltd Kelir
Fine Aggregate	: Sand from Wonosobo
Filler	:
Ash stone	: GMM Ltd, Kelir, Sub-district Kalipuro
Asphalt	: Penetration 60-70 of State-owned oil and gas company (Pertamina)
Tire Powder	: Waste from surrounding environment

Equipment

Equipment used includes:

a. A filter set: 3/4 ", ½", 3/8 ", No.4, No.8, No.16, No.30, No.50, No.100, No.200 and pan.
b. Oven equipped with a temperature control to heat up to 110
c. Frying tool
d. Weighing capacity 20 kg with accuracy of 1 gram (Heavy Duty Solution Balance).
e. Weighing capacity 2610 grams with precision 0.1 gram (Triple Beam Balance).
f. Wire basket size 3.35 mm with capacity 5 kg.
g. Water Batt.
h. Grate and tray
i. Straight Edge.
j. Screw
k. Marshall test.
l. Jack
m. Temperature.

3. Results and Discussion

Density check results for the number of collisions 2 x 75 times, with 0% mixed rubber tires.

Table 1: Concrete Density Asphalt number of impacts 2 x 75 times

Sample test	Asphalt level	Weight of test sample (gram			Vol. of test sample	B.D bulk camp
		In the air	In the water	SSD		
	A	E	F	G	H	J
From lab.	% Camp	From lab.	From lab.	From lab.	G-F	E:H
A	5.60	1180.6	657.8	1181.5	523.7	2.254
B	5.60	1192.4	658.8	1193.7	534.9	2.229
C	5.60	1170.4	648.7	1171.6	522.9	2.238
D	5.60	1165.4	650.7	1166.8	516.1	2.258
				Average		**2,245**

Density check results for the number of collisions 2 x 75 times, with 5% mixed rubber tires as shown in Table 1.

Table 2: Concrete Density Asphalt number of impacts 2 x 75 times

Sample test	Asphalt level	Weight of test sample (gram			Weight of test sample (gram)	B.D bulk camp
		In the air	In the water	SSD		
	A	E	F	G	H	J
From lab.	% Camp	From lab.	From lab.	From lab.	G-F	E:H
A	5.32	1182.6	659.8	1183.1	523.3	2.250
B	5.32	1179.4	657.8	1180.3	522.5	2.257
C	5.32	1159.4	645.7	1160.6	514.9	2.252
D	5.32	1171.4	647.7	1172.8	525.1	2.231
				Average		**2.250**

Density test results for the number of collisions 2 x 75 times, with 10% mixed rubber tires as in Table 2.

Table 3: Concrete Density Asphalt number of impacts 2 x 75 times

Sample test	Asphalt level	Weight of test sample (gram			Weight of test sample (gram)	B.D bulk camp
		In the air	In the water	SSD		
	A	E	F	G	H	J
From lab.	% Camp	From lab.	From lab.	From lab.	G-F	E:H
A	5.04	1183.9	661.8	1184.4	522.6	2.265
B	5.04	1180.1	659.8	1181.9	522.1	2.260
C	5.04	1167.2	645.7	1168.7	523.0	2.232
D	5.04	1172.4	657.7	1174.8	517.1	2.267
				Average		**2.256**

Density check results for the number of collisions 2 x 75 times, with 15% mixed rubber tires as in Table 3.

Table 4: Concrete Density Asphalt number of impacts 2 x 75 times

Sample test	Asphalt level	Weight of test sample (gram			Weight of test sample (gram)	B.D bulk camp
		In the air	In the water	SSD		
	A	E	F	G	H	J
From lab.	% Camp	From lab.	From lab.	From lab.	G-F	E:H
A	4.76	1193.9	669.8	1194.4	524.6	2.276
B	4.76	1190.1	667.8	1191.9	524.1	2.271
C	4.76	1187.2	665.8	1188.7	522.9	2.270
D	4.76	1192.4	668.7	1194.8	526.1	2.266
					Average	**2.271**

Density check results for the number of collisions 2 x 75 times, with 20% mixed rubber tires as shown in Table 4.

Table 5: Concrete Density Asphalt number of impacts 2 x 75 times

Sample test	Asphalt level	Weight of test sample (gram			Weight of test sample (gram)	B.D bulk camp
		In the air	In the water	SSD		
	A	E	F	G	H	J
From lab.	% Camp	From lab.	From lab.	From lab.	G-F	E:H
A	4.48	1187.9	665.8	1188.4	522.6	2.273
B	4.48	1185.1	663.8	1186.9	523.1	2.266
C	4.48	1184.2	660.8	1185.7	524.9	2.256
D	4.48	1186.4	664.7	1187.8	523.1	2.268
				Average		**2.266**

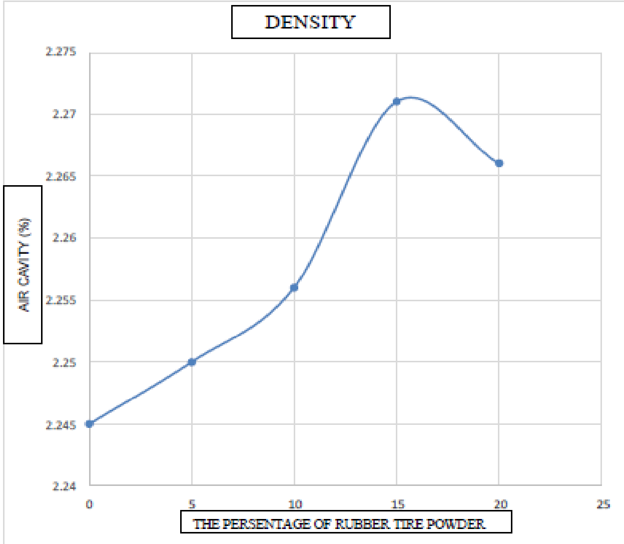

Figure 1: Graph of Relation of the percentage of used rubber tires to density values

Results of airborne cavity inspection and Marshall stability for the number of collisions 2 x 75 times, with 0% mixed rubber tires as in

Table 6: Air Cavity and Marshall Stability the number of collisions 2 x 75 times

Sampl test	Asphal	B.D	Weight of Test Sampl			Vol.	B.D	Air Activit	Stablity	
			n The A	In The Water	SSD				Read	Adjus
	A	B	E	F	G	H	J	K	L	M
rom La	% Cam	See No	rom L	rom L	From La	G-F	E-H	(BxJγT	rom L	From L
A	5.6	2.258	1180.(	657.8	1181.5	523.7	2.254	7.33	97.18	1166.
B	5.6	2.258	1192.4	658.8	1193.7	534.9	2.229	7.28	98.53	1170.3
C	5.6	2.258	1170.4	648.7	1171.6	522.9	2.239	7.3	98.18	1178.
D	5.6	2.258	1165.4	650.7	1166.8	516.1	2.258	7.34	97.16	1165.9
					verage		**.245**	**,31**		**170.1**

Results of airborne cavities and Marshall stability for the number of collisions 2 x 75 times, with 5% mixed rubber tires as in Table 6.

Table 7: Air Cavity and Marshall Stability the number of collisions 2 x 75 times

Samp test	Asphalt Level	B.D Bulk From Total AGG	Weight of Test Sample (Gram)			Vol. Sample Test	B.D Bulk Camp	Air Activity	Stablity	
			In The Air	In The Water	SSD				Read	Adjust
	A	B	E	F	G	H	J	K	L	M
From Lab.	% Camp.	See Note	From Lab	From Lab	From Lab	G-F	E-H	BxJγT)	From Lab	From Lab
A	5.32	2.258	1182.6	659.8	183.1	523.3	2.260	7.20	97.61	1171.3
B	5.32	2.258	1179.4	657.8	180.3	522.5	2.257	7.19	97.78	1173.3
C	5.32	2.258	1159.4	645.7	160.6	514.9	2.252	7.22	97.93	1175.1
D	5.32	2.258	1171.4	647.7	172.8	525.1	2.231	7.21	97.73	1172.8
						Average	**2.250**	**7.20**		**1173.1**

Results of airborne cavity inspection and Marshall stability for the number of collisions 2 x 75 times, with 10% mixed rubber tires as in Table 7.

Table 8: Air Cavity and Marshall Stability the number of collisions 2 x 75 times

Samp test	Asphal	B.D	Weight of Test Sample			Vol.	B.D	Air Activit	Stablity	
			n The A	In The Water	SSD				Read	Adjus
	A	B	E	F	G	H	J	K	L	M
From Lab.	% Camp	ee No	rom La	rom Lat	rom La	-F	-H	BxJγT)	rom L	rom La
A	.04	.258	183.9	61.8	184.4	22.6	.265	.11	8.03	176,3
B	.04	.258	180.1	59.8	181.9	22.1	.26	.13	8.11	177,3
C	.04	.258	167.2	45.7	168.7	23.0	.232	.14	8.26	179,1
D	.04	.258	172.4	57.7	174.8	17.1	.267	.16	8.07	176,8
					verage		**.256**	**.13**		**177.4**

Results of airborne cavity inspection and Marshall stability for the number of collisions 2 x 75 times, with 15% mixed rubber tires as in Table 8.

Table 9: Air Cavity and Marshall Stability the number of collisions 2 x 75 times

Sampl test	Asphal	B.D	Weight of Test Sample			Vol.	B.D	Air Activity	Stablity	
			In The Air	In The Water	SSD				Read	Adjust
	A	B	E	F	G	H	J	K	L	M
From Lab.	% Camp.	See Note	From Lab	From Lab	From Lab	G-F	E-H	(BxJγT)	From Lab	From Lab
A	4.76	2.258	1193.9	669.8	1194.4	524.6	2.276	7.05	98.84	1186.1
B	4.76	2.258	1190.1	667.8	1191.9	524.1	2.271	7.03	98.96	1187.5
C	4.76	2.258	1187.2	665.8	1188.7	522.9	2.270	7.02	99.01	1188.1
D	4.76	2.258	1192.4	668.7	1194.8	526.1	2.266	7.04	98.69	1184.3
					Average		**2.271**	**7.03**		**1186.5**

Results of airborne cavity inspection and Marshall stability for the number of of collisions 2 x 75 times, with 20% mixed rubber tires as in Table 9.

Table 10: Air Cavity and Marshall Stability the number of collisions 2 x 75 times

Sampl test	Asphal	B.D	Weight of Test Sample			Vol.	B.D	Air Activity	Stablity	
			In The Air	In The Water	SSD				Read	Adjus
	A	B	E	F	G	H	J	K	L	M
From Lab.	% Camp	See Note	From Lab	From Lab	From Lab	G-F	E-H	(BxJγT	From Lab	From Lab
A	4.48	2.258	1187.9	665.8	1188.4	522.6	2.273	7.05	98.6	1183.
B	4.48	2.258	1185.1	663.8	1186.9	523.1	2.266	7.06	98.44	1181.
C	4.48	2.258	1184.2	660.8	1185.7	524.9	2.256	7.04	98.76	1185.
D	4.48	2.258	1186.4	664.7	1187.8	523.1	2.268	7.05	98.82	1185.
					Average		**2.266**	**7.05**		**1183.**

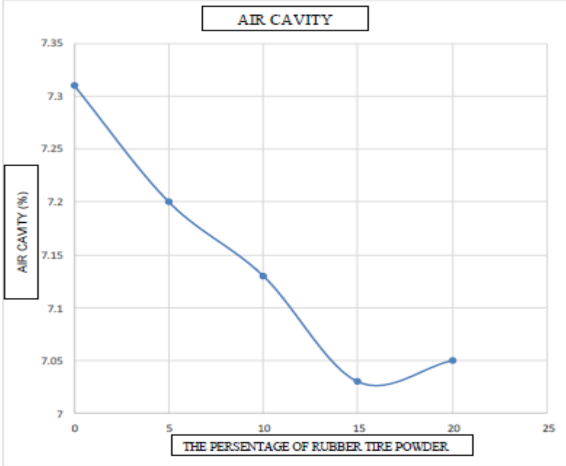

Figure 2: The Graph of Relation of the percentage of used rubber tires for Air Cavity

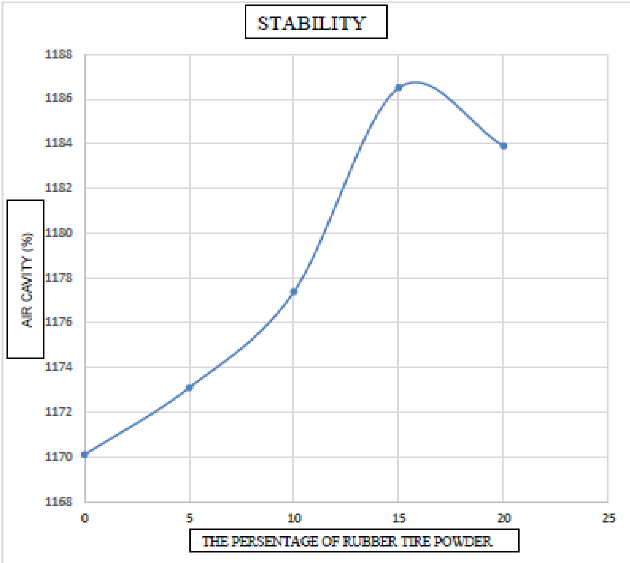

Figure 3: The graph of relation of the percentage of used rubber tires for Stability value

Examination Results of Melting for the number of collisions 2 x 75 times, with 0% mixed rubber tires as in Table 10.

Table 11: Asphalt Concrete Asphalt the number of collisions 2 x 75 times

Sample Test	Asphalt Level	Stability (Kg)		Flow (Mm)
		Read	Adjust	
	A	L	M	N
From Lab.	% Camp.	From Lab.	From Lab.	From Lab.
	A	L	M	N
A	5,60	97.18	1166.1	2.121
B	5,60	97.53	1170.3	2.235
C	5,60	98.18	1178.1	2.315
D	5,60	97.16	1165.9	2.035
AVERAGE			**1170.1**	**2.177**

Examination results of Melting for the number of collisions 2 x 75 times, with 5% mixed rubber tires as in Table 11.

Table 12: Asphalt Concrete Asphalt the number of collisions 2 x 75 times

Sample Test	Asphalt Level	Stability (Kg)		Flow (Mm)
		Read	Adjust	
	A	L	M	N
From Lab.	% Camp.	From Lab.	From Lab.	From Lab.
	A	L	M	N

A	5.32	97.61	1171.3	2.301
B	5.32	97.78	1173.3	2.331
C	5.32	97.93	1175.1	2.267
D	5.32	97.73	1172.8	2.257
AVERAGE			**1173.1**	**2.289**

Examination Results of Melting for the number of collisions 2 x 75 times, with 10% mixed rubber tires as in Table 12.

Table 13: Asphalt Concrete Asphalt the number of collisions 2 x 75 times

Sample Test	Asphalt Level	Stability (Kg)		Flow (Mm)
		Read	Adjust	
	A	L	M	N
From Lab.	% Camp.	From Lab.	From Lab.	From Lab.
	A	L	M	N
A	5.04	98.03	1176.3	2.335
B	5.04	98.11	1177.3	2.401
C	5.04	98.26	1179.1	2.356
D	5.04	98.07	1176.8	2.215
		Average	**1177.4**	**2.327**

Examination Results of Melting for the number of collisions 2 x 75 times, with 15% mixed rubber tires as in Table 13.

Table 14: Fatigue Concrete Asphalt number of impacts 2 **x 75 times**

Sample Test	Asphalt Level	Stability (Kg)		Flow (Mm)
		Read	Adjust	
	A	L	M	N
From Lab.	% Camp.	From Lab.	From Lab.	From Lab.
	A	L	M	N
A	4.76	98.84	1186.1	2.401
B	4.76	98.96	1187.5	2.376
C	4.76	99.01	1188.1	2.359
D	4.76	98.69	1184.3	2.511
		Average	**1186.5**	**2.411**

Examination results of Melting for the number of collisions 2 x 75 times, with 20% mixed rubber tires as in Table 14.

Table 15: Asphalt Concrete Asphalt the number of collisions 2 x 75 times

Sample Test	Asphalt Level	Stability (Kg)		Flow (Mm)
		Read	Adjust	
	A	L	M	N
From Lab.	% Camp.	From Lab.	From Lab.	From Lab.
	A	L	M	N
A	4.48	98.60	1183.2	2.467
B	4.48	98.44	1181.3	2.589
C	4.48	98.76	1185.1	2.678
D	4.48	98.82	1185.8	2.573
Average			**1183.9**	**2.577**

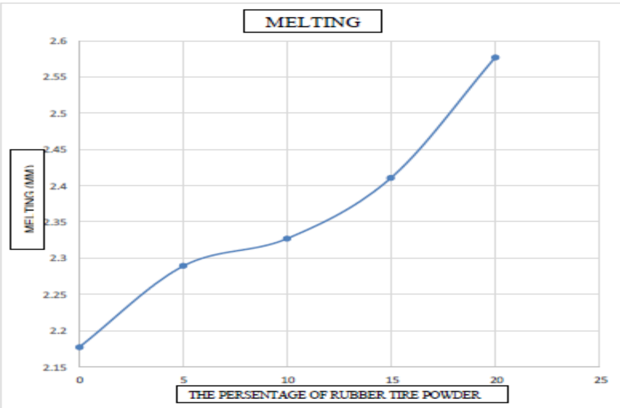

Figure 4: The graph of relation of the percentage of used rubber tires for value

The result of the study showed that the influences of rubber tire powder on hot mix asphalt concrete are:

1. Increasing the amount of asphalt concrete density value with mixed rubber tire powder has greatly increased, this can be seen in Figure 1 with a density value reaching 2.271 kg/cm3, with the number of collisions 2x75 times.
2. Increasing the amount of air cavity value of asphalt concrete with secondhand rubber tire decreased, this can be seen in Figure 2 with the value of the air cavity declining as it can fill the small cavities with a value of 7.03% at 2x75 times collision.
3. Improvement of stability value of optimum asphalt Marshall with used rubber tire powder can increase with value 1186.5 kg at 2x75 times collision number and this can be seen in figure 3.
4. With asphalt concrete using used rubber tire powder, the value of fatigue is bigger, but in terms of average it can be taken a decent percentage for fatigue value of asphalt concrete that is 15% powder of rubber tire used, and can be seen on Figure 4.

4. Conclusion

From the results of research variations on percentage value of rubber tire powder to asphalt concrete characteristics, it can be concluded that.

1. Examination of materials for asphalt concrete mixture meets Specification of Indonesian National Standard (SNI).
2. The used rubber tire powder has been qualified by passing No. screening. 50 (279 mm) in accordance with the provisions of (SNI) 03-6723-2002.
3. Effective bitumen level was calculated by Asphalt Institute method with effective middle asphalt level of 5.60%.
4. The average density for the same number of collisions is 2x75 times, with the highest density 2,271 kg / cm3. With the percentage of rubber tire powder used is 5% (2,250 kg / cm3), 10% (2,256 kg / cm3), 15% (2,271 kg / cm3), 20% (2,266 kg / cm3).
5. Marshall Stability of asphalt concrete with used rubber tire powder for same number of collisions is 2x75 times. Percentage of used rubber tire powder is 5% (1173,1 kg), 10% (1177,4 kg), 15% (1186,5 kg), 20% (1183,9) respectively.
6. The value of the air cavity in the test specimen with the value of the powdered tire content of the used rubber tires varies: 5% (7,20%), 10% (7,13%), 15% (7.03%), 20% (7.05 %) respectively.
7. Fatigue value for the percentage of used rubber tire powder is: 5% (2,289 mm), 10% (2,327 mm), 15% (2,411 mm), 20% (2,577 mm) respectively.
8. From the result of laboratory test above, it can be concluded that the content of the rubber powder mixture is effective towards the asphalt concrete with the content of rubber tire with the percentage of 15% from the optimum asphalt content of 4.76% asphalt value.

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