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The Influence of Immertion on Marshall Parameters and Residual Strength Index of Rubber Asphalt Mixture

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ABSTRACT

The bad drainage system in the road pavement area also causes the road body to be submerged in water for quite a long time, causing the bond between the asphalt and aggregate to loosen, resulting in decreased service life. Developments in the field of road construction have now implemented many innovative ideas, one of which is namely the use of rubber asphalt with asphalt containing natural rubber which has 1.5 to 2 times the strength compared to conventional asphalt. In evaluating the performance of an asphalt mixture, especially the AC-WC Wear layer mixture, it can be analyzed using the Marshall test method by taking into account the conditions being tested, namely the test object being immersion in water or continuously flooded with water. The method used in this research is an experiment with treatment conditions for AC-WC rubber asphalt mixture specimens which are continuously immersion in water for 1 day, 2 days and 3 days. The research results showed that there was an increase in the VMA, VIM, and flow parameters, while the VFB, stability, and Residual Strength Index parameters decreased with increasing soaking time. Based on the research results, it can be concluded that although there is an influence on the performance of the asphalt mixture with the use of rubber asphalt, the decrease that occurs is not too large and is still within the required specifications.

Keywords: *Rubber Asphalt; Immersion; Marshall Parameters; Residual Strength Index.*

INTRODUCTION

Road pavement damage in Indonesia is caused by several factors, namely traffic load, climate, material quality, and management of road construction implementation [1]. The results of previous research also stated that one of the causes of the current road damage is the low quality of the materials in the asphalt mixture. This, coupled with high traffic, loads and climate change conditions, namely the rainy and dry seasons, also causes damage to asphalt road pavement [2]. The bad drainage system in the road pavement area also causes the road body to be submerged in water for quite a long time, causing the bond between the asphalt and aggregate to loosen, resulting in reduced service life.

Developments in the field of road construction have currently seen many innovative ideas, one of which is the use of rubber asphalt with asphalt containing natural rubber. Test results state that rubber asphalt is 1.5 - 2 times more durable than conventional asphalt [4]. When compared with pure asphalt, rubber asphalt is more resistant to deformation (grooving), peeling of the asphalt layer with aggregate and is more resistant to cracking due to changes in environmental temperature [5]. However, the use of rubber asphalt still cannot compensate for the damage

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caused by changes in temperature and high traffic loads [3].

To determine the decrease in the stability value of road pavement due to water damage, or what is known as the Residual Strength Index, a comprehensive investigation needs to be carried out. The IKS value can be determined after the pavement layer has been soaked for 24 hours at a temperature of 60° C. Bearing in mind that the rainfall that occurs is often erratic, especially causing floods, the pavement layer can often be submerged for several hours or even days. Several areas in Indonesia that have quite high rainfall intensity, floods and poor drainage systems, often floods only recede after 3 days of soaking the pavement layers, as happened in East Kalimantan and South Kalimantan some time ago. So it is necessary to carry out several variations of immersion patterns to determine the damage behavior, especially related to marshall characteristics and residual strength index values in pavement layers using rubber asphalt.

METHODS

The type of research used was an experiment with treatment conditions for AC-WC rubber asphalt mixture specimens which were continuously submerged in water for 1 day, 2 days and 3 days. The research is a development of previous research [7]. The total number of test objects that will be made in this research is 33, 15 for determining KAO and 18 test objects with soaking time. The coarse, fine and stone ash aggregate materials use local materials from Petangis village, Paser Regency, East Kalimantar. With rubber asphalt as an aggregate binder. This research was carried out at the Laboratory of the Faculty of Civil Engineering and Planning, Balikpapan University, East Kalimantan. In this study, 3 variations of immersion of test objects were used to simulate the soaking time due to flood conditions, namely soaking for 1 day, 2 days and 3 days, at room temperature. After that, 3 samples will be soaked in a water bath at a temperature of 60° C for 30 minutes to determine the marshall characteristics and the other 3 samples will be soaked for 24 hours to determine the residual strength index.

Test Object Immersion Design

The Optimum Asphalt Content (KAO) used in this research is KAO of 6.25%. Next, immersion test specimens were made in KAO with the immersion design as follows in Table 1.

Table 1. Design for Immersion of Rubber Asphalt Mixture Test Objects

Soaking Time		**Soaking in a water bath with a temperature of 60° C**	
		30 Minutes	24 hours
A1	: 1 day	3 samples	3 samples
B1	: 2 days	3 samples	3 samples
C1	: 3 days	3 samples	3 samples

RESULTS AND DISCUSSION

Marshall Test Results

The aim of the Marshall test is to determine the performance of the rubber asphalt mixture using Marshall parameter measurement indicators and the Residual Strength Index after 24 hours of immersion, temperature 60° C. The following recapitulation of the immersion test results can be seen in Table 2 and Table 3.

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Table 2. Recapitulation of Test Results Due to Length of Soaking on Marshall Parameters

Immersion of Test Objects				
Parameter	A1	B1	B2	Specification
VMA	16.99	17.58	17.75	Min. 15
VIM	3.90	4.58	4.78	3-5
VFB	77.05	73.94	73.07	Min. 65
Stability	1,360	1,294	1,177	Min. 900
Flow	3.53	4.00	4.45	2-5

Table 3. Recapitulation of Residual Strength Index Parameter Test Results After 24 Hours Soaking

Immersion Code	Marshall Stability		IKS	Specification
	Soaking 30 minutes	Soaking 24 hours		
A1	1,360	1285	94.51	Min. 90 %
B1	1,294	1,213	93.74	
C1	1,177	1,092	92.79	

Based on the test results in Table 2 and Table 3, it states that continuous immersion for 1 day, 2 days and 3 days can affect the performance of the rubber asphalt mixture. The Marshall parameters tested were VMA, VIM, VFB, stability and flow, as well as the Residual Strength Index parameter after 24 hours of immersion. With reference to the 2018 Interim Special Specifications for Highways [8], and PUPR Ministerial Decree No. 04/SE/M/2019, concerning mixtures of rubber asphalt with asphalt containing natural rubber (Natural Rubber/NR).

Comparison Graph of the Effect of Soaking Time on Marshall Parameters and Residual Strength Index

Density of Voids in Aggregate (VMA)

The volume of voids between aggregate particles in a compacted asphalt mixture and expressed in percent.

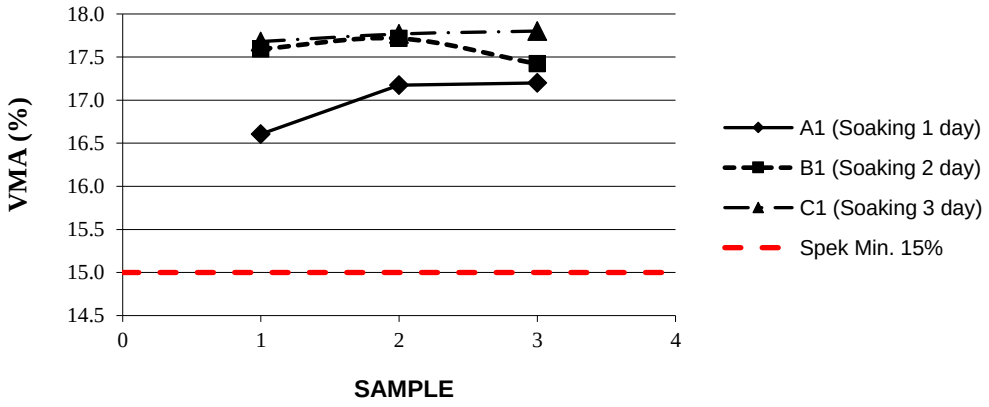

Figure 1. Comparison graph of the effect of soaking time for A1, B1, and C1 On the Density of Voids in Aggregate (VMA)

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Figure 1 shows that the VMA value increases with increasing soaking time. Soaking specimen C1 which was soaked for 3 days had the largest VMA value, namely 17.75%, followed by specimen B1 at 17.58%, and A1 at 16.99%. The test results of [9], stated that there was an increase in the VMA value with increasing soaking time. The inequality of voids in the mixture causes asphalt as an aggregate binder to not work optimally.

Cavity In Mixture (VIM)

VIM is a parameter that states the volume of voids in a mixture that contains air in percent. Figure 2 shows that the test object was soaked continuously. The largest VIM value occurred in the C1 soak with an average value of 4.78%, the B1 soak was 4.58% and the A1 soak was 3.90%. The VIM value increases with increasing soaking time [10], with an increase at each immersion in B1 of 0.68%, and C1 of 0.20%.

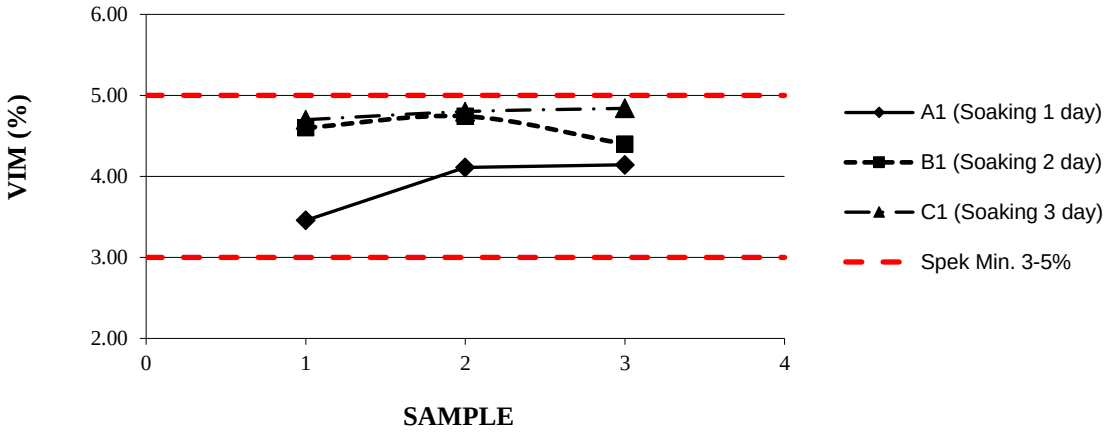

Figure 2. Grafik Perbandingan Pengaruh Perendaman A1, B1, dan C1 Terhadap Rongga dalam Campuran (VIM)

Asphalt Filled Cavity (VFB)

The volume portion of voids in aggregate (VMA) that is filled with asphalt and expressed in percent.

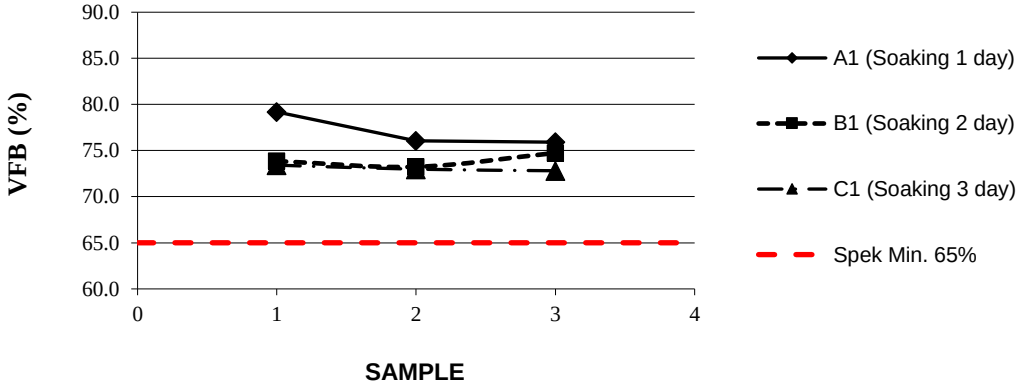

Figure 3: Comparison Graph of the Effect of Soaking A1, B1, and C1 on Asphalt filled voids (VFB)

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Figure 3 shows that an asphalt mixture that is continuously submerged in water can reduce the VFB value as the soaking time increases. This decrease occurs because the asphalt that fills the voids in the mixture is not distributed optimally as the soaking time increases. The average VFB value obtained from A1 immersion was 77.05%, B1 immersion was 73.94%, and C1 was 73.07%. Based on the results of previous research, it is stated that the longer the soaking time shows a tendency to decrease in the VFB value [10,11]

Stability

The ability of an asphalt mixture to withstand deformation due to constant repeated loading without causing failure, is expressed in kilograms/kg. Figure 4 shows that there was a decrease in stability parameters due to continuous soaking for 1 day, 2 days and 3 days. With a decrease from immersion A1 to B1 of 4.84% and from B1 to C1 a decrease of 9.06%. The average stability values obtained were 1360kg, 1294kg and 1177kg respectively. This is supported by the statements of [12,13], with the results that there is a decrease with increasing soaking time in the stability value of the asphalt mixture.

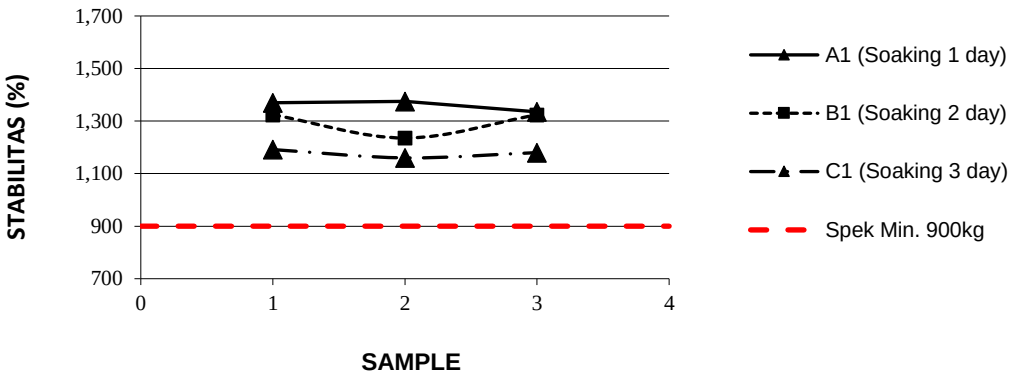

Figure 4. Comparison Graph of the Effect of Soaking A1, B1, and C1 Against Stability

Flow

The amount of deformation that occurs from the beginning of the loading to the maximum stability condition until the test object is destroyed is expressed in mm.

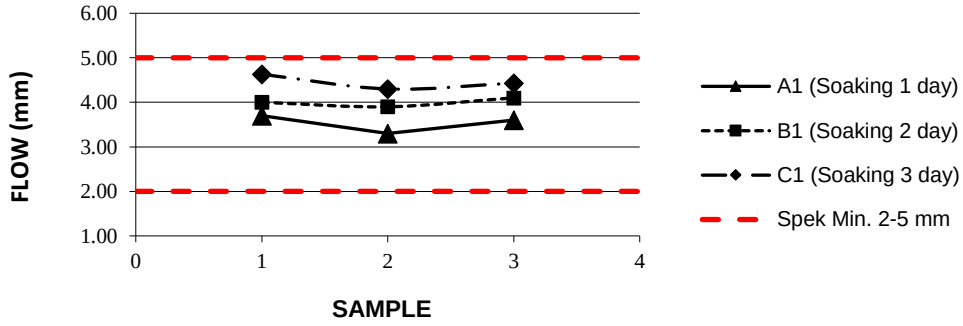

Figure 5. Comparison Graph of the Effect of Soaking A1, B1, and C1 Against Flow

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Figure 5 shows a comparative graph of the effect of soaking time on flow, where at 1, 2 and 3 days of soaking, the flow value increased. The average value of flow in the A1 bath was 3.53 mm, B1 was 13.21 mm and C1 was 4.00 mm. From immersion A1 to B1 there was an increase of 13.21% and from immersion B1 to C1 it increased by 11.33%. The research results of [14], concluded that there was an increase in the flow value as the soaking time increased, this also resulted in deformation due to vehicle loads and was plastic.

Residual Strength Index Due to the Effect of Soaking

Comparison of the stability value after 24 hours of immersion with the stability value of 30 minutes of immersion, at a temperature of 60° C and expressed as a percentage. Figure 6 shows a comparison graph of the effect of soaking time on the Residual Strength Index. The Residual Strength Index is a comparative value of stability after 24 hours with an immersion temperature of 60° C. The results show that there was a decrease of 0.077% from immersion A1 to B1 and from immersion B1 to C1 decreased by 0.95%. The average residual strength index value was obtained respectively. amounting to 94.51%; 93.74% ; 92.79%. According to [15], there is a decrease with increasing soaking time on asphalt pavement. This occurs due to loss of adhesion/stirpping, most aggregate materials have a greater attractive force on water compared to asphalt. The cause of the decrease in the soaking process results in a decrease in the stability value of the asphalt mixture [16].

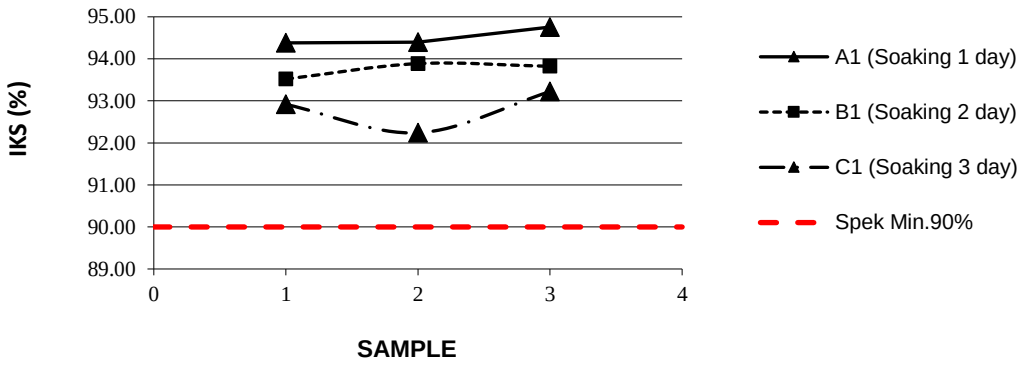

Figure 6. Comparison Graph of the Effect of Soaking A1, B1, and C1 on Residual Strength Index

Discussion

Based on the research results, it can be concluded that the effect of water immersion on the Marshall parameters VMA, VIM and Flow values increases with increasing immersion time. Meanwhile, the VFB and Stability parameters decreased as the soaking time increased. And the Residual Strength Index parameter after soaking for 24 hours at a temperature of 60° C also decreased. It can be stated that although there is an influence on the performance of the asphalt mixture with the use of rubber asphalt, the reduction that occurs is not too large and is still within the required specifications.

Based on Figures 1 to 6, it can be seen that the soaking time affects the durability level of the asphalt mixture. The decrease in stability value along with the length of soaking indicates that the asphalt mixture experiences strength degradation. This decrease can be caused by damage due to water infiltration into the cavity of the asphalt mixture. Long soaking can damage the structural integrity of the mixture because water will reduce the cohesive properties and stiffness of the asphalt. The presence of voids on the surface of the mixture will provide an

opportunity for water to infiltrate into the structure of the mixture which then enlarges the voids in the mixture. The longer the soaking period, the more water will penetrate and cause greater damage.

Another reason that can reduce the stability value is because water reduces the adhesion force between asphalt and aggregate in the mixture. As can be seen in Figure 6. The longer the soaking results in the pavement layer structure becoming brittle and less durable because the adhesion force becomes weaker. The minimum residual strength index limit indicated by Bina Marga is 90% but the use of rubber asphalt mixture after soaking according to the existing pattern still meets this standard where the residual strength index value of variation A1 is 94.5%, variation B1 is 93.4% and variation C1 or which was soaked for 3 days had a value of 92.8%, meaning that the use of rubber asphalt provided quite good strength stability even though it had been soaked for 3 consecutive days. compared to the use of conventional asphalt or 60/70 penetration asbuton which only has a residual strength index of 92% after being soaked for 1 days, 90% after being soaked for 2 days and even lower, namely 87% after being soaked for 3 days [16].

CONCLUSIONS

For further research, it is hoped that we can use different methods of measuring the performance of rubber asphalt mixtures and soaking them for longer durations so that we can find out to what extent the performance of the rubber asphalt mixture is able to withstand the effects of water immersion and the load received.

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