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A Change in the Indeks of Retained Strength in the AC-WC Mixture with The Additional Waste Rubber from Used Tires (Crumb Rubber)

Kurniawan Hidayat[a], Tantin Pristyawati[a], and Hendramawat Aski Safarizki[a]
[a] Civil Engineering Department Faculty of Engineering, Veteran Bangun Nusantara University, Jl. Letjen Sudjono Humardhani No.1, Sukoharjo, Indonesia, 0271-593156
e-mail: kurniawanhidayat001@gmail.com, tantintsipil@gmail.com, hendra.mawat@gmail.com

Kata kunci:

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ABSTRAK

Pertumbuhan jumlah kendaraan bermotor di Indonesia setiap tahunnya selalu meningkat. Konsekuensi dari pertumbuhan jumlah kendaraan bermotor tersebut adalah meningkatnya produksi ban kendaraan bermotor yang mengakibatkan menumpuknya limbah ban bekas. Salah satu inovasi untuk mengurangi limbah karet ban bekas adalah dengan memanfaatkannya dalam campuran aspal. Penelitian dilakukan untuk mengetahui perubahan indeks kekuatan sisa pada campuran *Asphalt Concrete – Wearing Coarse* (AC-WC), merupakan lapis perkerasan yang terletak paling atas yang berfungsi sebagai lapisan keausan dengan penambahan limbah karet ban bekas *(crumb rubber)* yang memenuhi Spesifikasi Bina Marga. Hasil penelitian menunjukkan bahwa penambahan limbah ban karet berpengaruh terhadap karakteristik marshall yaitu nilai berat jenis, berat jenis, *Voids Filled with Asphalt* (VFA), dan stabilitas tertinggi berada pada taraf 1%, sedangkan nilai *Voids in Mix* (VIM), *Void in Mineral Agregate* (VMA), dan *flow* tertinggi. berada pada level 9%. Dari uji index of retaining strength menunjukkan bahwa air berpengaruh terhadap keawetan campuran AC-WC, dibuktikan dengan nilai tertinggi pada lama perendaman selama 24 jam dengan konsentrasi 1% yang semakin menurun dengan bertambahnya lama waktu. dari perendaman. Penambahan limbah karet ban bekas *(crumb rubber)* ke dalam campuran AC-WC telah memenuhi Spesifikasi Bina Marga pada uji karakteristik Marshall, namun perubahan indeks kekuatan retensi hanya pada lama perendaman 24 jam, sedangkan untuk jangka waktu lain tidak sesuai dengan Spesifikasi Bina Marga.

Keyword:

crumb rubber;
marshall;
indeks of retained strength

ABSTRACT

The growth of the number of motorized vehicles in Indonesia every year always increases. The consequence of the growth in the number of motorized vehicles is the increasing production of motorized vehicle tires which results in the accumulation of used tire waste. One of the innovations to reduce the waste of used tire rubber is to use it in asphalt mixtures. The study was conducted to determine the change in the index of retained strength in the Asphalt Concrete – Wearing Coarse (AC-WC), is the top layer of pavement which functions as the wear layer, mixture with the addition of waste rubber from used tires (crumb rubber) meeting the Bina Marga Specifications. The results showed that the addition of waste rubber tires affected the Marshall characteristics, namely, the highest specific gravity, density, Voids Filled with Asphalt (VFA), and stability values were at a level of 1%, while the highest values of Voids in Mix (VIM), Void in Mineral Aggregate (VMA), and flow were at a level of 9%. From the index of retained strength test, it shows that water affects the durability of the AC-WC mixture, as evidenced by the highest value at the duration of immersion for 24 hours with a concentration of 1%, which decreases with increasing duration of immersion. The addition of used tire rubber waste (crumb rubber) to the AC-WC mixture has met the Bina Marga Specifications on the Marshall characteristics test, but the change in the index of retained strength was only for a 24-hour immersion duration, while for other durations were not according to the Bina Marga Specifications.

1. INTRODUCTION

The growth in the number of motorized vehicles in Indonesia every year always increases [1]. Recorded by the Central Statistics Agency (BPS), in 2018, there were 126,508,776 vehicles, and in 2019 there was an increase of 5% to 133,617,012 vehicles, while in 2019, there were 126,508,776 vehicles. In 2020 there were 136,137,451 vehicle units, an increase of approximately 2% from the previous year [2]. As a result of the growth in the number of motorized vehicles, which is increasing every year, is the increasing production of motorized vehicle tires, which results in the accumulation of used tire waste. Tire production in Indonesia continues to increase in line with the growth in the number of motorized vehicles, and it is recorded that in 2016 Indonesia was able to produce 70.2 million units of four-wheeled vehicle tires which increased by 5.80% on average and 61.87 million units. Two-wheeled vehicle tires experienced an average increase of 11.65% compared to 2011 [3].

On the other hand, the growth in the number of motorized vehicles is a problem related to the road pavement structure [4]. Based on data from the Ministry of Public Works and Public Housing (PUPR) in 2019, out of 47,017,270 km of national roads in Indonesia, 975,355 km, or approximately 2.07%, are in a badly damaged condition requiring repairs. National roads with good condition reached 44.89%, moderate condition 47.92%, and slightly damaged condition 5.12%. One of the efforts that can be made to avoid heavy road damage is to improve the quality of the pavement layer.

According to [5], the addition of crumb rubber powder to the AC-WC (asphalt concrete-wearing course) worn layer mixture with variations of 2%, 4%, 6%, 8%, and 10% can increase the stability value, MQ, and VFA. Still, the value of flow, VIM, and VMA decreased. The results of the research on the type of AC-BC (asphalt concrete - binder course) mixture [6] also revealed that grated used tires with levels of 0%, 1%, 2%, 3%, 4%, and 5% affect the value of Marshall parameters, especially the value of stability, VIM, and VMA at a certain asphalt content. Meanwhile, in the treated base asphalt mixture with 0%, 1.5%, 3%, 4.5%, and 6% waste tire powder content, the more used tire powder was added, the lower the stability value. The flow value increases with used tire powder [7].

Water affects the durability of the asphalt concrete mixture [8], as indicated by a decrease in the stability value in the index of retained strength (IRS) test as the duration of immersion increases [9]. Improving the quality of asphalt road pavements can be done by modifying the physical and chemical properties of the asphalt pavement forming materials with various additives to obtain better quality, minimize spending on road infrastructure, and provide comfort to society and the state [10]. One of the innovations being developed in various countries for additives for asphalt road pavement mixtures is waste tires (crumb rubber) [11], [12]. Crumb rubber can improve the major problem of the dry mix method in asphalt mixture, especially in the poor interaction between asphalt binder and additive, causing improper workability [13]–[16]. Mixing temperature and exposure temperature affect the strength of asphalt with crumb rubber mixture [17].

Based on the previous background, the research aims to find out how the index of retained strength changes in the AC-WC mixture with the addition of used tire rubber waste (crumb rubber) and to compare the test results with the 2018 Bina Marga specifications.

2. METHODS

2.1 Materials and Tools

The main ingredients in AC-WC asphalt mixture are 60/70 penetration asphalt, coarse aggregate, fine aggregate, portland cement filler, and waste tire rubber (crumb rubber). The tools used can be grouped into several, namely, aggregate testing tools (testing specific gravity and material absorption, as well as wear testing), Marshall characteristics testing tools, and index of retained strength.

2.2 Research Methodology

The research was carried out using an experimental research method by making a mixture of asphalt concrete wearing course (AC-WC) according to the Bina Marga specifications and adding rubber waste from used tires (crumb rubber) with a percentage, as well as variations in the length of immersion in the water bath to determine the durability of the index of retained strength.

This research was conducted in stages. Testing is carried out starting from fine and coarse aggregate testing. Aggregate testing includes sieve analysis, weight aggregate type, absorption, and wear and tear. The next test is on the asphalt mixture testing process using the Marshall test.

3. RESULTS

3.1 Material Characteristic Test Result

Material characteristic testing is carried out following Indonesian National Specifications and Standards. The results of testing the characteristics of materials as shown in Table 1 – 3.

Table 1. Material that passes sieve no. 200

NO.	MATERIAL TYPE	CONDITION		RESULT
		MIN	MAX	
1	Coarse Aggregate	-	1 %	0,704 %
2	Medium Aggregate	-	1 %	0,780 %
3	Fine Aggregate	-	10 %	6,733 %

Table 2. Wear/Abrasion

MATERIAL TYPE		CONDITION		RESULT
		MIN	MAX	
Coarse Aggregate	100 Rounds	-	8 %	4,66 %
	500 Rounds	-	40 %	21,80 %

Table 3. Specific Gravity and Arbsobtion

Specific Gravity and Arbsobtion	CA	MA	FA
Bulk Density (gr/cc)	2,606	2,596	2,579
Saturated Surface Dry Density (SSD) (gr/cc)	2,645	2,640	2,623
Apparent Density (gr/cc)	2,712	2,716	2,699
Absorption (gr/cc)	1,499	1,702	1,719

Furthermore, a combined grading analysis is carried out. The method used to find the combined aggregate percentage is trial and error. If the calculation results do not meet specifications will be repeated sieving analysis tests, results combined sieving calculation (combined grading result can be seen in Fig. 1)

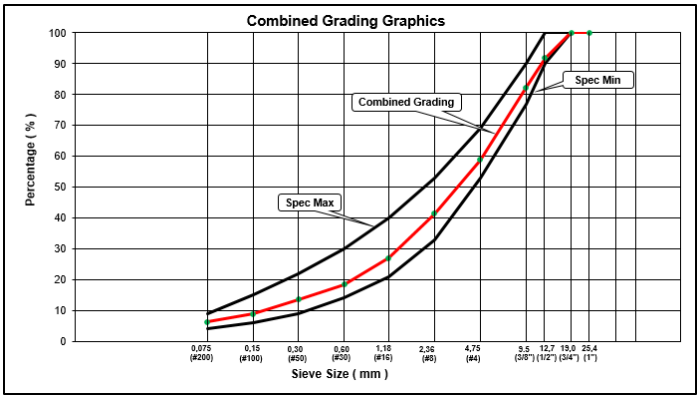

Figure 1. Combined Grading Graphics

3.2 The Result of Making Test Object

The results of testing the characteristics of Marshall with variations in asphalt content (5%, 5.5%, 6%, 6.5%, and 7%) were made of 15 specimens (each variation of asphalt content of three specimens) obtained. The result of the selected asphalt content is 5.7%, as shown in Fig. 2.

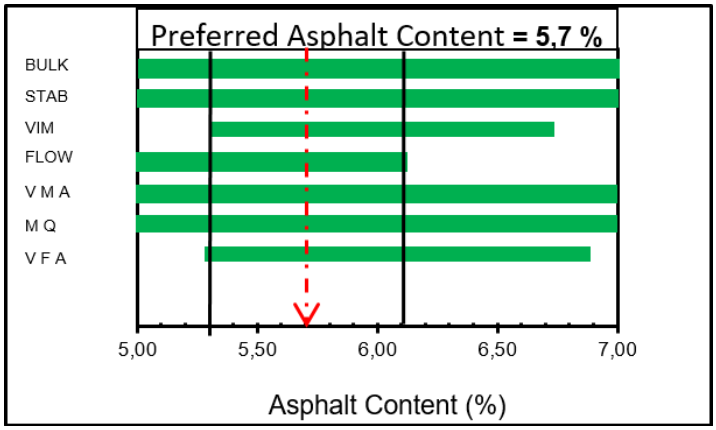

Figure 2. Preferred Asphalt Content

3.3 Marshall Characteristic Test Result

The results of the Marshall characteristic test following SNI 06-2489-1991. This test aims to determine the specific gravity of aggregate, void in mix (VIM), void in material aggregate (VMA), void filled with asphalt (VFA), stability, flow, and mar-shall quotient (MQ). The following are the results of testing Marshall characteristics, as shown in Table 4, Fig. 3 - 9.

Table 4. The specific gravity of aggregate

No	Calculation	Result (gr/cc)
1	Average Bulk Density of Aggregate (Gsb)	2,595
2	Effective Specific Gravity of Aggregate (Gse)	2,654
3	Maximum Density of Mixture (Gmm)	2,418

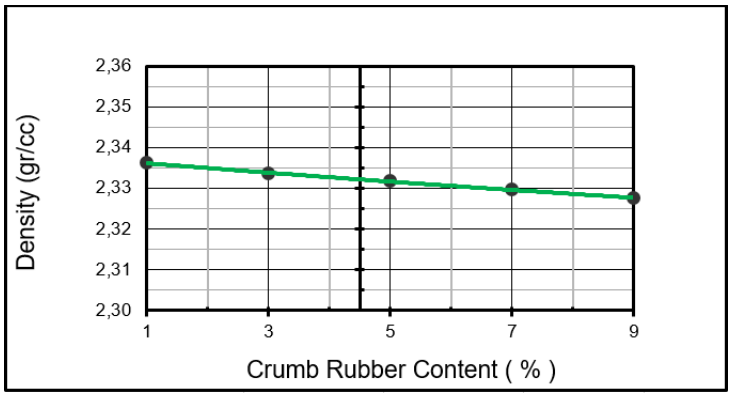

Figure 3. Density Graphics

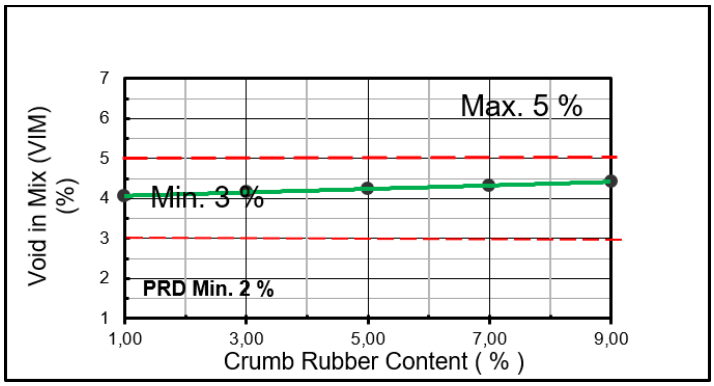

Figure 4. Void In Mix (VIM) Graphics

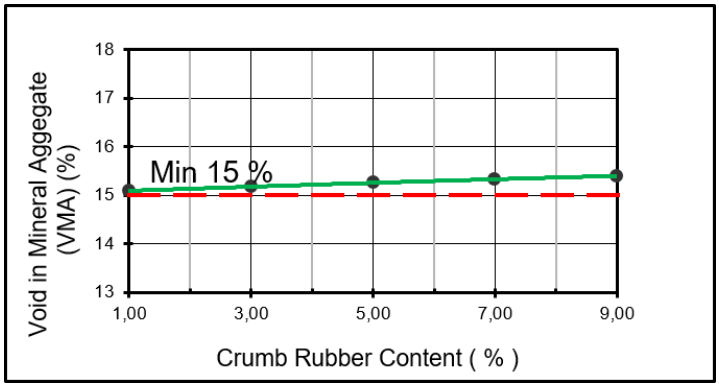

Figure 5. Void In Mineral Aggregate (VMA) Graphics

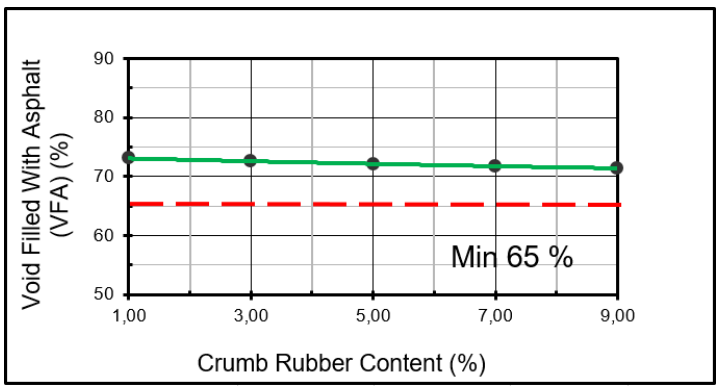

Figure 6. Void Filled with Asphalt (VFA) Graphics

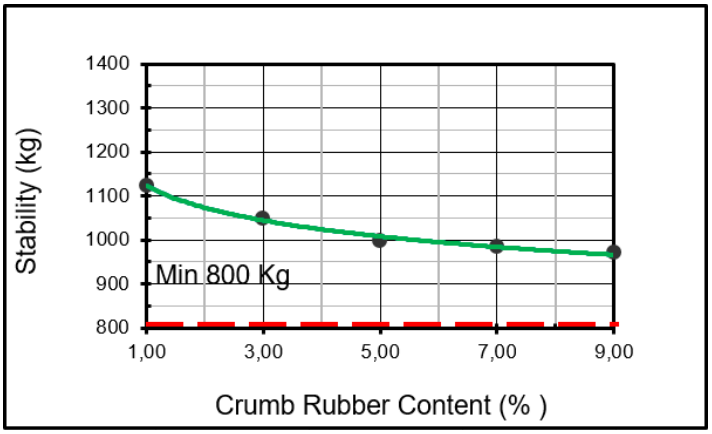

Figure 7. Stability Graphics

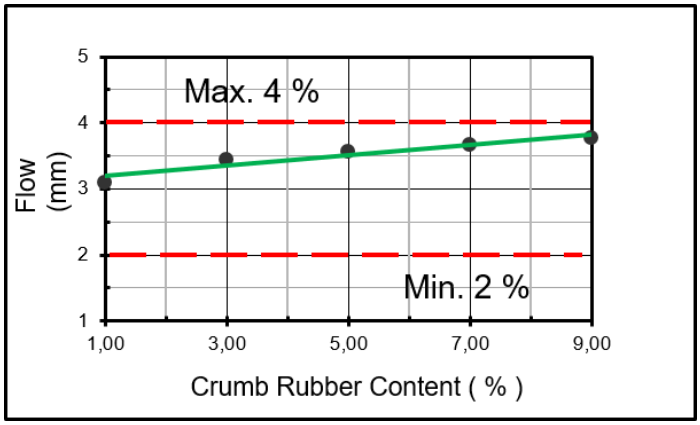

Figure 8. Flow Graphics

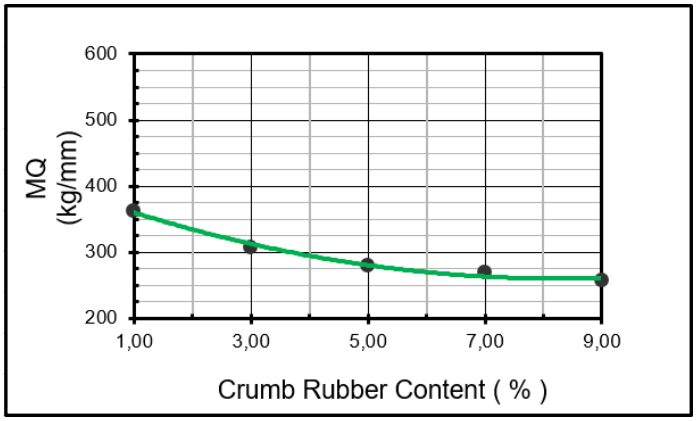

Figure 9. Marshal Quotient Graphics

3.4 Index of Retained Strength Test Result

Index of retained strength is a comparison of immersion of the test object in water at a temperature of 60 °C for 1 day / 24 hours with standard stability, which aims to determine the durability or durability of the mixture. Fig. 10 shows the value of the variation in the duration of immersion, namely 24 hours, 48 hours, and 72 hours, to determine the index of retained strength.

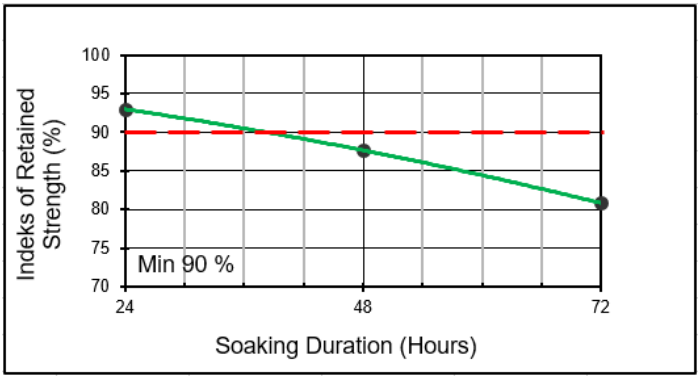

Figure 10. Index of Retaine Strength Graphics

The more waste rubber tires (crumb rubber) on the asphalt concrete wearing course (AC – WC) mixture decreases the value of mixed specific gravity. Decreasing the value of the specific gravity of the mixture will increase void in the mix (VIM) and void in mineral aggregate (VMA) values. Increasing VIM and VMA values tend to lower void filled with asphalt values (VFAs). From testing the stability value, it decreased along with adding waste rubber tires (crumb rubber) levels, while the value flow increased.

The decrease in the specific gravity of the mixture is due to its flexibility owned by rubber which results in cavities in the mixture asphalted after receiving a load at high temperatures or under hot circumstances.

4. CONCLUSION

Based on the results of the analysis of the Marshall characteristics and the index of retained strength (IRS), the following conclusions can be drawn:

1. The addition of waste rubber used in tires (crumb rubber) affects the value of Marshall characteristics.
2. Water affects the durability of the asphalt concrete wearing course (AC–WC) mixture, indicated by the decrease in the value of the Marshall characteristics as the duration of immersion increases.
3. Analysis of Marshall characteristics on the addition of used tire rubber waste (crumb rubber) to asphalt mixture asphalt concrete wearing course (AC-WC) meets the specifications while the analysis of residual stability value/index of retained strength (IRS), duration 24-hours immersion meets the specifications. Still, for the duration of immersion, 48 hours, and 72 hours, it is below the 2018 Highways General Specification for Road and Bridge Construction Works Revision 2.

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