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Importance of the Relationship Between VMA And Permeability on the Durability Properties by Using Crumb Rubber with Different Percentage Portions

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Abstract

For the past ten years, engineers have been deeply researching the permeability of asphalt concrete. High-air voids have generally been the main indicator of permeable hot asphalt concrete in the work that has been done. The prediction of the field permeability values is inconsistent with that indicated in the current published literature. Furthermore, the precise correlations between the various components influencing the field permeability are unclear and complex.

One of our objectives of this research work is to present the investigations performed using the modelling of Hot Mix Asphalt's (HMA's) field permeability using crumb rubber (CR). The primary benefit of using crumb rubber in asphalt mixture is to produce pavement that could be friendly and environmentally acceptable from a duration usable point of view. Other benefits of this procedure are to decrease the friction phenomena on pavement surfaces and improve the mechanical and long-term qualities of the asphalt mixture. This study's findings are presented to explore the benefits of employing crumb rubber to minimize excessive water infiltration and optimize field permeability.

This paper offers a significant and straightforward method for comprehending the variables influencing permeability. Asphalt was modified using a fine crumb rubber shred (2.36 - 0.85 mm) that was produced by grinding used truck tires at room temperature. Using the dry process method, the fine crumb rubber with varying contents (2.5%, 4.5%, and 6.5%) was added to the mixture. Hot Mix Asphalt's (HMA) field permeability must be regulated to avoid excessive water infiltration, which can cause an early failure of asphalt pavements.

Keywords: Rutting, Asphalt, Hot mix, Permeability specification, and Durability

1. Introduction

Climate variables like using tires from abandoned cars to improve pavement construction have been considered as a first step in this research work. Another significant point of concern is the oxidative deterioration of asphalt layers phenomena. Over the last few decades, a lot of research work has been focused on creating modified asphalt materials that will help in improving pavement performance and durability. The correct disposal of worn tires is a serious environmental risk in many countries. There have been multiple attempts in the past to modify asphalt mixtures with the use of crumb rubber. CR! To enhance paving mixes performance rubber scraps that have been mechanically sheared or ground into tiny pieces are known as crumb rubber. There were moments when some questions were raised about the usefulness of CR as an asphalt modifier [6].

The primary benefit of employing Crumb Rubber Modifiers (CRM) in the manufacturing of asphalt mixtures is the pavements' environmental sustainability, which is linked to the possibility of recycling industrial waste materials. Additionally, the incorporation of mechanical properties into the mixtures is made possible by the use of CRM [5].

2. The Use of CRM in Asphalt Mixes

While truck tires mostly consist of natural rubber (NR), car tires are commonly made of a synthetic rubber copolymer called Styrene-Butadiene-Rubber (SBR), which is composed of styrene and butadiene. (M. Cerchiai and Massimo Losa1 (2012) The CRM utilized in this study is produced by mechanically grinding used tires at room temperature; these tires are made up of 50% used truck tires and 50% used automobile tires. The size gradation of CRM utilized to create gap-graded mixes by the WP and DP is shown in Figure 1, superimposed on the standard CRM gradations for AR manufacturing. Crumb Rubber Modifiers (CRM) in both size categories meet the specifications needed to produce AR. Since CRM in this study permits a partial reaction with bitumen, as opposed to the typical DP, which requires crumb rubber to have dimensions in the range of 0–6 mm, we deal with CRM for both the mixes made using the wet and dry processes.

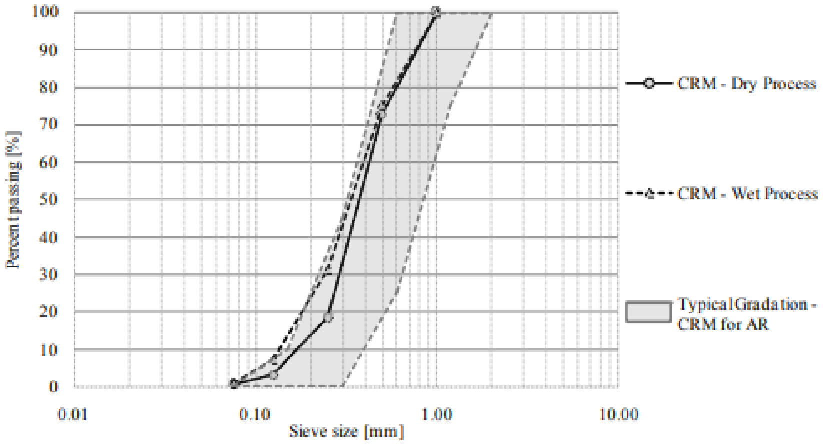

Fig 1: Size Gradations of CRM.

3. Materials and Properties

For this investigation, coarse aggregate, fine aggregate, and asphalt (AC60/70) were the primary materials employed. Every aspect of the materials utilized was measured to facilitate more examination and thought. To measure their qualities by the mentioned specifications the AASHTO and Bina Marga Standard several tests were carried out.

A. Aggregate

Tables 1 and 2 display the aggregates' physical characteristics. The coarse and fine aggregates used in this study were open-graded crushed tomato stone and river sand, respectively. A matrix that regulates the cohesion and flow of the material was created by adding a tiny quantity of sand.

Table 1: Properties of the Fine Aggregate

No	Properties	Result	Specification (Bina Marga)
1	Bulk specific gravity	2.52	≥2.5
2	SSD specific gravity	2.59	≥2.5
3	Apparent specific gravity	2.723	≥2.5
4	Water absorption	2.94	≤3.0

Table 2: Properties of the Coarse Aggregate

No	Properties	Result	Specification (Bina Marga)
1	Bulk specific gravity	2.64	≥2.5
2	SSD specific gravity	2.67	≥2.5
3	Apparent specific gravity	2.714	≥2.5
4	Water absorption	1.02	≤3.0
5	Abrasion	21.31	≤40
6	Adhesiveness	99	≤95

B. Asphalt

One type of asphalt with a 60/70 penetration grade was used in this study. Property testing was done on PT Pertamina’s AC60/70 asphalt. Tests conducted on asphalt 60/70 confirmed that its properties comply with the specifications of the State Corporation for roads and bridges in Indonesia, The physical properties of asphalt are presented in Table 3.

Table3: Properites of Asphalt AC 60/70

No	Characteristics	Result	Specification (Bina Marga)
1	Specific gravity of asphalt	1.045	Min. 1
2	Penetration (mm)	63.5	60 -79
3	Ductility (cm)	164	Min. 100
4	Flash point and fire point ©	320-326	Min. 200
5	Softening point (c)	48.35	48 - 58
6	Asphalt solubility in TCE (tri chore ethylene)/CCL	99.59	Min. 99

C. Permeability

The permeability of an asphalt concrete mix can be determined using two values: the permeability coefficient of k (cm/second) or the permeability value of k (cm). The commonly used empirical method of hydraulic analysis can be used to approximate the value of permeability. The permeability specification of the Materials Divisions tabulates that an asphalt mixture must have a maximum permeability of 150 x 10-5 cm/sec in order to ensure low permeability during construction [7].

4. The test of permeability

This test approach was adopted as a standard testing process, and it followed the guidelines for bitumen material permeability found in ASTM PS 129-01 [11]. The aluminium cylinder used as the permeability device in the lab has measurements of 13 cm for length and 11 cm for internal diameter. An interior rubber sleeve within the cylinder made the vertical flow descend and prevented horizontal flow. Darcy's law for the falling head permeability test requires that the water used in the experiment be heated to 20°C. The device is displayed in Figure 1. The Darcy test of falling head permeability was used to measure the coefficient of permeability (K); the testing procedure used by Kanipong, et al (2010) produced inconsistent and non-repeatable results. Lack of a technique to guarantee the saturation status of samples is one possible reason.The greatest variation of 4% between the obtained permeability data cannot be directly used to explain the ability of HMA using crumb rubber to carry fluid because the degree of saturation cannot be assured or controlled by the two testing intervals for a single sample.

5. The durability properties

Testing for permeability is crucial because impermeable pavement is a prerequisite for modern pavement, which is one of the main tenets of the sturdy architecture of concrete pavement (asphalt concrete). This design strategy's major goal is to minimize moisture absorption in order to retain sufficient protection against the loose materials that support it. The OBC permeability check results are displayed in Table 4. The results are summarized for each type of HMA in OBC in Figure 1. The following formula is used to get the coefficient of permeability: where the diameter.

(D) = 2.54*4 = 10.16 cm

Height (L) = 6.127 cm

$$\text{Area (A)} = \frac{\pi \times D^2}{4} = \frac{\pi \times (10.16)^2}{4} = 79.756\ \text{cm}^2 \ldots\ldots (1)$$

Pressure water (P) = 10 kg/cm²

Volume of water leakage (V) = 1000 ml

Time leakage 1000ml = 194 sec @(10Kg/cm²).

$\gamma = 1\ \text{gr/cm}^2$.

Coefficient of permeability

$$(k) = \frac{V \times L \times \gamma}{A \times P \times T} = \frac{1000 \times 6.15 \times 1}{79.756 \times 10 \times 103} = 3.96\text{E-}07\ \text{cm/sec} \ldots\ldots (2)$$

Table 4 Comparison of Permeability Test at OBC

CR %	Asphalt Content	Height (L) (cm)	Area (A) (cm^2)	Water pressure and N2 1 kg / cm^2		Water pressure and N2 2 kg / cm^2	
				Time (T) sec	Permeability lt / sec	Time (T) sec	Permeability lt / sec
0	6.10	6.150	79.756	103	0.010	42	0.024
	6.10	6.316	79.756	78	0.013	31	0.032
	6.10	6.116	79.756	110	0.009	48	0.021

	Average				**0.011**		**0.026**
2.5	6.20	6.433	79.756	46	0.022	20	0.050
	6.20	6.283	79.756	88	0.011	43	0.023
	6.20	6.666	79.756	43	0.023	18	0.056
	Average				**0.019**		**0.043**
4.5	6.25	6.630	79.756	46	0.022	19	0.053
	6.25	6.583	79.756	43	0.023	22	0.045
	6.25	6.400	79.756	42	0.024	23	0.043
	Average				**0.023**		**0.047**
6.5	6.35	7.200	79.756	23	0.043	15	0.067
	6.35	6,766	79.756	40	0.025	24	0.042
	6.35	6.650	79.756	30	0.033	18	0.056
	Average				**0.034**		**0.055**

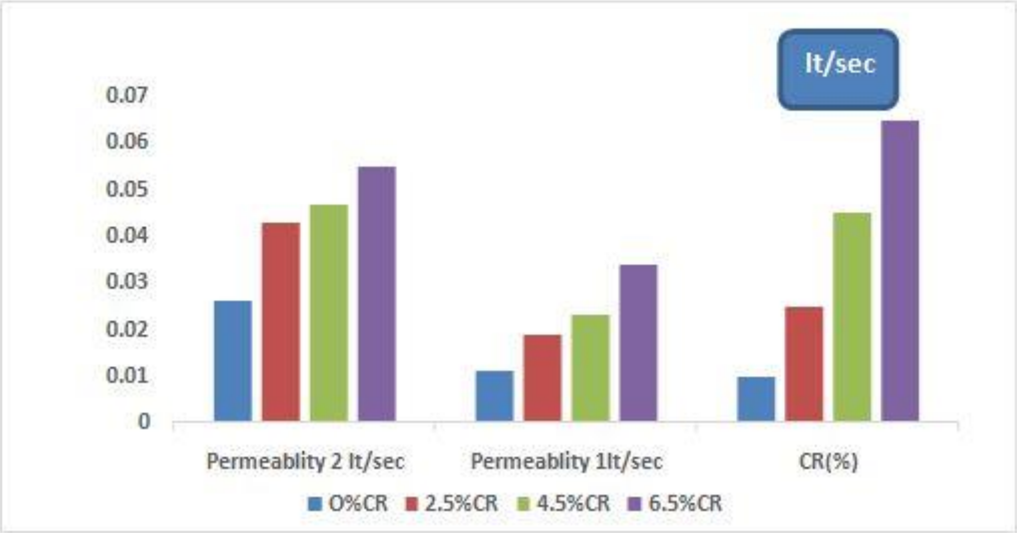

Fig 1: The results of the permeability test

The first permeability is 0.011 cm/sec for the crumb rubber-type 0% on OBC 6.10%, and the second permeability is 0.026 cm/sec. The first permeability is 0.019 cm/sec for crumb rubber with a 2.5% content on OBC 6.20%, and the second permeability is cm/sec. The first permeability is 0.023 lt/sec and the second permeability is 0.047 cm/sec for a 4.5% crumb rubber content at OBC 6.25% cm/sec. The first permeability is cm/sec for crumb rubber with a 6.5% content at OBC 6.35%, and the second permeability is 0.055 lt /sec. In the fast water flow of samples, the effect of utilizing a different type of crumb is best when the optimum bitumen concentration is at 6.35 and lowest when it is at 6.10%. After looking over the permeability test findings in Table 1 and Figure 1, the following observations were made. The coefficient of permeability (K) of the asphalt concrete HMA with CR is greater than that of the concrete HMA without CR (original), and it increases with 2.5% and 4.5% CR by 0.055 and 0.034 cm/sec, respectively, at a water pressure of 10000 dyne/cm2 and 0.034 cm/sec.

Because the combination has the lowest coefficient of permeability and greater quality when water escapes into the soil layer (base course), causing cracks and holes, the results of the permeability check show that HMA concrete without crumb rubber is superior to HMA concrete with crumb rubber. There is an inverse relationship between the permeability coefficient and water pressure: as water pressure rises, the permeability coefficient falls it was the most permeability-optimal outcome. In contrast to results with 4.5% CR and 6.5% CR, the test with 2.5% CR produced results of 0.019 cm/sec and 0.043 cm/sec for the second permeability. One may argue that samples with a greater CR content failed more quickly than samples with a lower CR content at particular permeability levels. From this point on, the 2.5% CR mix outlasts the other mix that contains crumb rubber.

6. Conclusions

- Because of the humid weather and heavy precipitation phenomena that occur throughout the year in most orient tropical nations like Indonesia, hot mix asphalt concrete containing 2.5% CR is the recommended ratio that can be adopted for road pavement construction in these nations. This percentage also protects the hot asphalt concrete mixture from premature deterioration caused by rain.
- The coefficient of permeability and water pressure show a rising correlation, suggesting that HMA concrete with 2.5% crumb rubber is preferable to HMA concrete without crumb rubber because the permeability coefficient of HMA concrete without crumb rubber decreases as water pressure rises.
- Permeability test indicates that the asphalt concrete without crumb rubber has a lower permeability than that with crumb rubber. However, their combination results in an inverse relationship between the permeability coefficient and water pressure. As the water sweeps into the base course of the soil, the defects, fissures, and holes will be visible at which the water pressure increases. At the same time, the permeability coefficient decreases consequently [10].

7. Recommendations for Further Research Work

1. The above third conclusion point in this research work indicates that there is an inverse relationship between coefficient of permeability and water pressure while it is moving through soil layer under **A**sphalt **C**oncrete **P**avement (**ACP**). Further research works in this aspect are extremely necessary.
2. From construction point of view, the heavy load (Stresses and Strains) results from using the road and its durability are important points have to be considered in future research works.
3. The availability of the row materials (Disposable Used Truck Tiers) from which the crumb rubber will be produced could be a critical point in producing the road pavement for long term.

References

1. Bina Marga, (1983), PetunjukPelaksanaan Lapis AspalBeton (LASTON) UntukJalan Raya. Public Work Departments, Jakarta
2. M. Emin Kutay1 and Ahmet H. Aydilek (2007) Dynamic Effects on Moisture Transport in Asphalt Concrete JOURNAL OF TRANSPORTATION ENGINEERING 10.1061/ ASCE0733-947X-;133:7(406).
3. BinaMarga, (2006), PetunjukPelaksanaan Lapis AspalBeton (LASTON) UntukJalan Raya. Public Work Departments, Jakarta.
4. P. J. Vardanega, A.M.ASCE1 and T. J. Waters2 (2011) , Analysis of Asphalt Concrete Permeability Data Using Representative Pore Size JOURNAL OF MATERIALS IN CIVIL ENGINEERING © ASCE / FEBRUARY / 16

5. Massimo Losa1 and M. Cerchiai2 (2012) Improvement of Pavement Sustainability by the Use of Crumb Rubber Modified Asphalt Concrete for Wearing Courses International Journal of Pavement Research and Technology Vol.5 No.6 Nov.
6. Soon-Jae Lee, Hakseo Kim, Chandra K. Akisetty, and Serji N. Amirkhanian (2008) Laboratory characterization of recycled crumbrubber-modified asphalt mixture after extendedagingCan. J. Civ. Eng. 35: 1308–1317
7. G. W. Maupin, Jr., P.E (2010) FINAL REPORT EXAMINATION OF AN IMPLEMENTED ASPHALT PERMEABILITY SPECIFICATION Virginia Transportation Research Council, 530 Edgemont Road Charlottesville, VA 22903-2454, www.vtrc.net, (434) 293 -1900
8. Kanitpong, K., C. H. Benson., and H. U. Bahia, (2001) Hydraulic Conductivity of Laboratory Compacted Asphalt Mixtures. Transportation Research Record: Journal of the Transportation Research Board, Volume 1767/2001, Page 25-32, Washington, D.C
9. BinaMarga, (2014), PetunjukPelaksanaan Lapis AspalBeton (LASTON) UntukJalan Raya Public Work Departments, Jakarta.
10. LHWAINT (2020), Design and properties of crumb rubber aggregates replacement in hot mixture asphalt concrete. TRANSPORTION ENGINEERING AND MANAGEMENT
11. ASTM International. ASTM PS 129-01: standard provisional test method for measurement of permeability of bituminous paving mixtures using a flexible wall permeameter. ASTM International, West Conshohocken, PA; 2001, p. 1–5.