

THE EFFECT OF FISH BONE POWDER WASTE AS A FINE AGGREGATE SUBSTITUTION IN ASPHALT CONCRETE WEARING COURSE PAVEMENT

Tiar Wahyudi¹, Yonas Prima Arga Rumbyarso², Bermando Mangatur Siagian³

^{1,2,3}Department of Civil Engineering, Krisnadwipayana University
Email : tiaravanks93@gmail.com

ABSTRACT

Roads as transportation infrastructure play an important role in regional development and are used to transport basic necessities. Certain materials with specific durability are used for road construction, but damage can occur due to natural phenomena, excessive pressure, or material quality. This damage can endanger drivers and often causes accidents. The Bina Marga Road Maintenance Manual lists various types of damage, but this study only focuses on inspections to detect cracks. In Muara Angke, Central Jakarta, one ton of fish bone waste is produced every month from the fish cracker making process. This waste, which produces an unpleasant odor and contains BOD, COD, and TSS, pollutes the environment and makes the 400 m² industrial area unhealthy. Due to lack of skills and technology, local communities have not been able to process or utilize this fish bone waste effectively. The results of Marshall testing on the composition of AC-WC asphalt using fish bone powder waste with variations of fine aggregate substitution of 0%, 25%, and 50%, and asphalt content of 5%, 6%, and 7% did not meet the 2018 Bina Marga specifications for Stability, Void in Air, Marshall Quotient, and Void in Material values. The Marshall characteristics obtained from the mixture with fish bone powder waste are not comparable to the regular AC-WC mixture without waste. In addition, the VIM value for the mixture with 6% asphalt content and waste variations of 0%, 25%, and 50% also did not meet Bina Marga standards. However, all VMA and VFA levels still meet the asphalt and aggregate specification criteria according to Bina Marga 2018.

Keywords: Asphalt, Asphalt Concrete Wearing Course, Fish Bone.

INTRODUCTION

Roads as transportation infrastructure play an important role in regional development and are used to transport basic necessities. Certain materials with specific durability are used for road construction, but damage can occur due to natural phenomena, excessive pressure, or material quality. This damage can endanger drivers and often causes accidents. The Bina Marga Road Maintenance Manual lists various types of damage, but this study only focuses on inspections to detect cracks. In Muara Angke, Central Jakarta, one ton of fish bone waste is produced every month from the fish cracker making process. This waste, which produces an unpleasant odor and contains BOD, COD, and TSS, pollutes the environment and makes the 400 m² industrial area unhealthy. Due to lack of skills and technology, local people have not been able to process or utilize this fish bone waste effectively.

METHODS

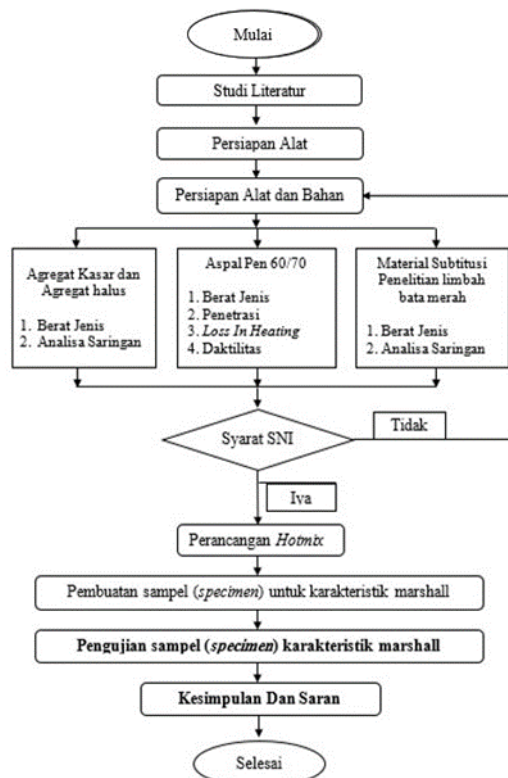


Figure 1. Research Flowchart

This research was conducted from May to June 2024 at the Asphalt Laboratory, Civil Engineering Study Program, Faculty of Engineering, Krisnadwipayana University, Jakarta. This study tested asphalt concrete wearing course samples with varying percentages of fish bone powder waste used as filler.

The filler must not contain unwanted components and must be able to pass through sieve No. 200. In addition, additional filler materials must be free from lumps and in a dry condition. In this study, the bantak filler used was able to pass through sieve No. 200. The filler specifications described in SNI 1994 are presented in Table 4 below:

Table 4. Filler Aggregate Requirements

No.	Karakteristik	Standar Pengujian	Satuan	Spesifikasi	
				Min.	Maks.
	<i>Filler</i>				
	Material yang lolos saringan No. 200	SK SNIM-02-1994-03	%	70	-
1	Berat Jenis	AASHTO T-85 -81		-	-
2					

The tools used in this study include digital scales, digital sieves, ovens with a temperature of $(110 \pm 5)^{\circ}\text{C}$, ordinary sieves, asphalt ductility tools, pycnometers, thermometers, stopwatches, soaking tubs, electric stoves, molding, extruders, Marshall test tools, compactor hammers, and specific gravity and absorption measuring tools for coarse aggregates.



Figure 2. Digital Filter

RESULTS AND DISCUSSION

Penetration testing evaluates asphalt hardness by inserting a needle into a standard sample at a temperature of 25°C with a load of 50 grams for 5 seconds. The results of this test show a penetration value of 64.75, which corresponds to an asphalt penetration level in the range of 60/70.

Table 5. Asphalt Penetration Test

Room Temperature : 31 °C		Water Temperature : 25 °C	Dampness : 55 °C
Pouring Temperature : °C		Duration Penetration : (5 ± 0,5) Sec	
Conditions Test	Ballast Use : 50 Grams	Temperatur Test : 25 °C	
Number Test		I	II
1. Penetration Measurement I (0,1 mm)		61	59
2. Penetration Measurement II (0,1 mm)		69	70
3. Deviation test I & II (0,1 mm)		8	11
4. Average Result I & II (0,1 mm)		65	64.5
5. Max Deviation From Measurement (0,1 mm)		11	
6. Average Measurement 1,2,3 (0,1 mm)		64,75	
7. Measurement Result level Penetration		B	

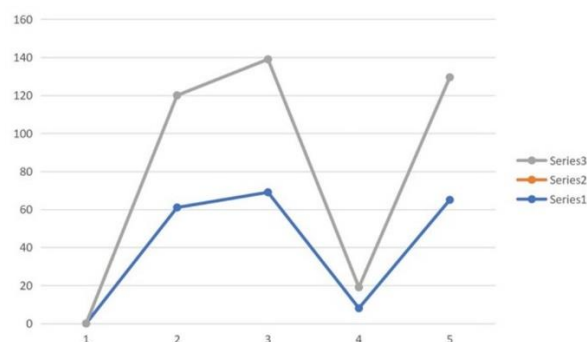


Figure 3. Asphalt Penetration Test Graph

The sieve analysis test is conducted to determine the percentage of material that passes through various sieve sizes.

Table 6. Cement Filler Sieve Test

No. Saringan	Berat Tertahan (gram)				Jumlah Berat Tertahan (gram)	Jumlah Tertahan (%)	Jumlah Lolos (%)
	I	II	III	Rata- Rata			
1"	-	-	-	-	-	-	-
3/4"	0	0	0	0	0	0	100
1/2"	0	0	0	0	0	0	100
3/8"	0	0	0	0	0	0	100
No. 4	0	0	0	0	0	0	100
No. 8	0	0	0	0	0	0	100
No. 16	0	0	0	0	0	0	100
No. 30	0	0	0	0	0	0	100
No. 50	1,2	2,3	2,1	1,87	1,87	0,09	99,91
No. 100	15	18	15	16	17,87	0,83	99,17
No. 200	23	25,2	28,4	25,5	27,4	1,63	98,37

Table 7. Fish Bone Powder Waste Filler Sieve Test

No. Saringan	Berat Tertahan (gram)			Jumlah Berat Tertahan (gram)	Jumlah Tertahan (%)	Jumlah Lolos (%)
	I	II	Rata- Rata			
1"	-	-	-	-	-	-
3/4"	0	0	0	0	0	100
1/2"	0	0	0	0	0	100
3/8"	0	0	0	0	0	100
No. 4	0	0	0	0	0	100
No. 8	0	0	0	0	0	100
No. 16	0	0	0	0	0	100
No. 30	0	0	0	0	0	100
No. 50	0	0	0	0	0	100
No. 100	0	0	0	0	0	100
No. 200	95,7	36,8	66,3	132,5	22,48	77,52
Jumlah	95,7	36,8	66,25	132,5	100	

According to SNI 0013-81, the standard specific gravity of filler is between 2.25 – 2.7 gr/cm³. In this study, the specific gravity of cement filler is 2.36 gr/cm³ and the specific gravity of fish bone powder waste filler is 2.44 gr/cm³. Based on the filler material standards, both types of filler are suitable for use as components in the manufacture of laston asphalt concrete wearing course.

Table 8. Specific Gravity Analysis Test of Cement and Fish Bone Powder Waste

Tempratur Ruangan : 31 °C	Air : 25 °C	Oven : 105 °C	Kelembaban : 55 °C
Contoh :			
1. Nomor Pemeriksaan	filler semen		kapur tohor
2. Berat Picometer (W1) (CC)	60,1 gr		60,1 Gr
3. Berat Picometer + Contoh (W2) (CC)	147,0 gr		150,7 Gr
4. Berat Pic + Contoh + Air (W3) (CC)	215,0 gr		218,4 Gr
5. Berat Pic + Air (W4) (CC)	164,9 gr		164,9 Gr
6. Berat Jenis	$\frac{2-1}{4(-1-3)2}$		2,44 Gr
	2,36 gr		

The composition of the asphalt mixture or dense asphalt concrete was designed in the Concrete Laboratory of the Faculty of Civil Engineering, Krisnadwipayana University. The experiment determined the composition of hot bin I at 42%, hot bin II 37%, hot bin III 20%, with the addition of 1% cement filler and asphalt content of 5.7%.

Table 9. Cement Filler Planning Output

Material		Kadar	
Kadar Aspal Optimum		6	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		7,2	Gram
Berat Agregat Kasar (Hot Bin I)	: 17%	204	Gram
Berat Agregat Sedang (Hot Bin II)	: 45%	540	Gram
Berat Agregat Halus (Hot Bin III)	: 32%	384	Gram
Filler Semen	: 6%	72	Gram
Filler Limbah Serbuk Tulang Ikan	: 0%	1,2	Gram

Table 10. Design of 40% Fish Bone Powder Waste Filler

Material		Kadar	
Kadar Aspal Optimum		6	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		7,2	Gram
Berat Agregat Kasar (Hot Bin I)	: 17%	204	Gram
Berat Agregat Sedang (Hot Bin II)	: 45%	540	Gram
Berat Agregat Halus (Hot Bin III)	: 32%	384	Gram
Berat Filler Total	: 6%	72	
Filler Semen dari Berat Total Filler	: 60%	43,2	Gram
Filler Limbah Serbuk Tulang Ikan dari Berat Total Filler	: 40%	28,8	Gram
Total :		1200	Gram

Table 11. Results of Design of 80% Fish Bone Powder Waste Filler

Material		Kadar	
Kadar Aspal Optimum		6	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		7,2	Gram
Berat Agregat Kasar (Hot Bin I)	: 17%	204	Gram
Berat Agregat Sedang (Hot Bin II)	: 45%	540	Gram
Berat Agregat Halus (Hot Bin III)	: 32%	384	Gram
Berat Filler Total	: 6%	72	
Filler Semen dari Berat Total Filler	: 20%	14,4	Gram
Filler Limbah Serbuk Tulang Ikan dari Berat Total Filler	: 80%	57,6	Gram
Total :		1200	Gram

The test showed that the fish bone powder filler, with a stability result of 2487 kg at a variation of 40% and 2568 kg at a variation of 80%, had higher stability compared to the cement filler which reached 2266 kg. Stability, which measures the ability of the pavement mixture to withstand loads until melting (flow) occurs, is influenced by internal friction and the thickness of the asphalt layer. The stability value of fish bone powder meets the Bina Marga standard which requires a minimum of 2200 kg, so fish bone powder has the potential to be an effective substitute for cement filler. The test results showed that the value of voids in aggregate (VMA) differed depending on the type of filler used. With cement filler, the VMA was 27.90%. However, with the use of fish bone powder filler at a variation of 40%, the VMA value increased to 36.51% and at a variation of 80%, the value increased further to 37.31%. This shows that the use of fish bone powder filler produces a higher volume of void space in the aggregate compared to the use of cement filler, meeting the minimum criteria of 18% required by Bina Marga 2018.

The test shows that the mixture with cement filler has a flow value of 3.35 mm, while with fish bone powder filler the flow value is 3.35 mm at a variation of 40% and 3.40 mm at a variation of 80%. This shows that the mixture using fish bone powder filler requires more asphalt, resulting in smaller air gaps and the potential for increased plastic deformation during

loading. Although the flow value of the mixture with fish bone powder waste filler is higher, it still meets the Bina Marga criteria which stipulates a flow range of 2 to 4 mm.

The pore volume remaining after compaction of the asphalt mixture is known as the pore volume of dense asphalt concrete (VIM). The test shows that the VIM value of the mixture with cement filler is 16.17%. Meanwhile, for the mixture with fish bone powder filler, the VIM value was 26.19% at 40% variation and 27.12% at 80% variation. The use of fish bone powder filler increases VIM, indicating the presence of more air cavities due to larger grains compared to cement filler. Although the flow value is higher in the mixture with fish bone powder filler (3.35 mm for 40% variation and 3.40 mm for 80% variation), the mixture still meets the Bina Marga flow criteria which range from 2 to 4 mm. Both types of filler, cement and fish bone powder, meet the 2018 Bina Marga specifications which set a minimum VIM of 3.5-5.5%. The Marshall Quotient (MQ) value indicates the ratio of flow to stability, which describes the stiffness and flexibility of the mixture. The higher the MQ value, the harder the mixture, and the lower, the more flexible. From the test, the MQ value for the mixture with cement filler was 676 kg/mm. In the study using fish bone powder, the MQ value was 742 kg/mm at 40% variation and 756 kg/mm at 80% variation, indicating that the mixture with fish bone powder had higher stiffness compared to cement filler. However, both types of fillers met the minimum Bina Marga 2018 specification of 250 kg/mm.

CONCLUSIONS

The Marshall test results on the AC-WC asphalt composition using fish bone powder waste with fine aggregate substitution variations of 0%, 25%, and 50%, and asphalt content of 5%, 6%, and 7% did not meet the 2018 Bina Marga specifications for Stability, Void in Air, Marshall Quotient, and Void in Material values. The Marshall characteristics obtained from the mixture with fish bone powder waste were not comparable to the regular AC-WC mixture without waste. In addition, the VIM value for the mixture with 6% asphalt content and waste variations of 0%, 25%, and 50% also did not meet the Bina Marga standards. However, all VMA and VFA levels still met the asphalt and aggregate specification criteria according to Bina Marga 2018.

REFERENCES

- Achmad, F. A., & Rumbyarso, Y. P. A. (2023). Analisis Struktur Slab On Pile terhadap Kontrol Lendutan pada Proyek Jalan Tol Kataraja. *Jurnal Pendidikan Tambusai*, 7(2), 13457-13467.
- Abdillah, S. R., Zulfikar, S., & Prima, Y. (2023). PENGARUH LIMBAH CANGKANG KERANG SEBAGAI SUBSTITUSI AGREGAT HALUS TERHADAP KUAT TEKAN BETON. *Jurnal Sipil Krisna*, 9(1), 39-48.
- Fitriyana, L., Ni'am, M. F., Jabra, M. M. M., & Mulya, E. R. (2024, April). Heave in the Soil due to Driving Pile Foundations. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1321, No. 1, p. 012036). IOP Publishing.
- Fitriyana, L., & Arbianto, R. (2019). Analisa Galian Berdasarkan Metode Element Hingga. *Jurnal Teknik Sipil dan Arsitektur*, 24(2), 33-37.
- Gamaliel, B. (2024). IMPLEMENTATION OF AN ELECTRO-PNEUMATIC SYSTEM IN A VALVE SAFETY SUPPORT DEVICE THROUGH LINEAR TO ROTATIONAL MOTION. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(01), 15-20.
- Hartanto, B. G. (2024). PELATIHAN SISTEM PERPIPAAN DAN PERAWATAN SERTA SERVIS AC BAGI MAHASISWA POLITEKNIK NEGERI MEDIA KREATIF. *KRIDA CENDEKIA*, 3(01).

- Kusumo, B. Simulasi Rancang Bangun Alat Pemberi Pakan Ayam Dan Monitoring Suhu Kandang. *Journal of System and Computer Engineering (JSCE) ISSN (online)*, 2723, 1240.
- Kusumo, B. (2024). Rancang Bangun Jemuran Otomatis Berbasis Sensor Water Drop dilengkapi Panel Surya 10 WP. *JURNAL KRIDATAMA SAINS DAN TEKNOLOGI*, 6(01), 127-145.
- Pribadi, G., Rumbyarso, Y. P. A., & Sakti, E. M. S. (2023). Pelatihan Merancang Gambar Dengan Aplikasi Autocad untuk Pembekalan Siswa SMK dalam Memasuki Dunia Kerja. *Media Abdimas*, 2(2), 52-56.
- Pribadi, G., & Rumbyarso, Y. P. A. (2023). Analisis Profil Atap Baja WF dengan Metode LRFD Menggunakan SAP 2000 dan Idea StatiCa. *Jurnal Teknik Industri Terintegrasi (JUTIN)*, 6(4), 1543-1559.
- Rumbyarso, Y. P. A. (2023). Re-planning of Concrete Structures in the Ngoro Dormitory Project in Surabaya. *Journal of Applied Science, Engineering, Technology, and Education*, 5(1), 15-24.
- Rumbyarso, Y. P. A. (2022). Analisis Perkuatan Rangka Atap Baja pada Bangunan Gedung Heritage 1921 Menggunakan Software SAP 2000. *Jurnal Teknik Indonesia*, 1(1), 1-8.
- Rumbyarso, Y. P. A. (2023). Penyuluhan Komposisi Campuran Beton untuk Jalan Tol. *Journal of Social Work and Empowerment*, 2(3), 137-144.
- Rumbyarso, Y. P. A., & Pribadi, G. (2023). Analisis Stabilitas Lereng dengan Metode Bishop pada Proyek Geotechnical Investigation Jalur Transportasi Pelabuhan Batubara Marangkayu Kabupaten Kutai Kartanegara. *JURNAL KRIDATAMA SAINS DAN TEKNOLOGI*, 5(02), 562-577.
- Rumbyarso, Y., Chusna, N., & Khumaidi, A. (2022). Dissolved Oxygen Prediction of the Ciliwung River using Artificial Neural Networks, Support Vector Machine, and Streeter-Phelps. *Jurnal Ilmiah Merpati (Menara Penelitian Akademika Teknologi Informasi)*, 10(3), 180-190.
- Rumbyarso, Y. P. A., & Pribadi, G. (2022). Penyuluhan Tentang Pentingnya Sebuah Kontruksi Bagunan Rumah Yang Baik Serta Tahan Gempa. *Krida Cendekia*, 1(08).
- Rumbyarso, Y. P. A., & Pribadi, G. (2024). Analysis of Landslide Handling With Mini Pile Reinforcement Using Plaxis Software on The “X” Toll Road Project. *Jurnal Teknik Industri Terintegrasi (JUTIN)*, 7(2), 801-810.
- Rachmansyah, A., Darmiyanti, L., & Kusumaningrum, R. (2023, October). Expansive Soil Improvement Using Electrochemical Injection. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1249, No. 1, p. 012039). IOP Publishing.
- Windasari, W., & Darmiyanti, L. (2004). Pengaruh Jarak Dukungan Lateral terhadap Kapasitas Lentur Balok Vierendeel.