Microstructure of Asphalt Mixtures Using Empty Palm Oil Bunch Waste as Filler Based on Road Engineering Association of Malaysia (Ream) Specifications

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ABSTRACT

Performance of Hollow Asphalt Mixtures Using Empty Palm Oil Bunches Waste Based on Road Engineering Association of Malaysia (Ream) Specifications. One of the road pavement technologies currently being developed is porous asphalt. One of the materials used in flexible pavement mixtures is filler, one of which is ash. stone, which is in limited supply and relatively expensive. One alternative solution is to use empty oil palm fruit bunches. waste as an alternative material in the asphalt mixture. The aim of this research is what is the microstructure of asphalt mixtures that use empty oil palm fruit bunches as filler. This research uses the specifications of the Road Engineering Association of Malaysia (REAM, 2008). From the results of the research carried out, it can be concluded that the use of stone ash filler from empty palm fruit fruit bunches in hollow asphalt mixtures with variations of 2.5%, 5% and 7.5% shows that the granules are dense with voids that cover each other with varying sizes. This is in line with the stability value obtained from the Marshall test. Which has increased due to interlocking of interlocking grains. Meanwhile, from the EDS test results on the composition of chemical elements, it is known that the element contained in the hollow asphalt sample mixed with ash from burning empty oil palm fruit bunches with the highest compound composition is the element Boron at 66.55%, which is different from the chemical composition test for burning ash from bunch waste. The highest compound composition based on atomic percentage is Potassium (K) at 31.6%.

Keywords: waste of empty palm oil bunches (TKKS), porous asphalt, REAM, microstruktur SEM-EDS

INTRODUCTION

Road pavement technology has gradually begun to develop in terms of the quality and quality of transportation infrastructure. One of the road pavement technologies currently being developed is porous asphalt. According to [1], [2] porous asphalt is an asphalt mixture designed to have higher porosity than other types of pavement, the porous nature is obtained because the porous asphalt mixture uses a smaller proportion of fine aggregate than other mixtures. One of the materials used in flexible pavement mixtures is filler, one of which is rock ash, which is limited in supply and relatively expensive. Therefore, it is necessary to find alternative uses for other materials with good quality, but have relatively cheaper prices. One alternative solution to overcome the problem of palm oil waste is to utilize it as an alternative material in the asphalt mixture. In this case, researchers want to use another type of filler, namely palm oil fiber ash [3]-[6]. Especially in West Sulawesi, on every hectare of oil palm plantations, solid waste is produced around 4 - 4.6 tons per year in the form of empty bunches and is the largest solid waste from the palm oil industry. However, so far the simplest and fastest waste management is by burning or even some are left to rot on the side of the road which is very disturbing to drivers and the surrounding community and causes pollution to the environment. This palm fiber ash is obtained from the process of burning palm fiber so that it then becomes ash [7]-[10].

SEM-EDS testing in this study was carried out to determine the microstructure and composition of elements contained in asphalt. SEM (Scanning Electron Microscopy) electron microscope produces sample images by scanning the surface with a focused electron beam with a magnification of up to

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a certain scale. used to study the surface morphological structure and cross section of a material with a magnification of up to 1,000,000 X [11]-[13].

In 2022, oil palm development in West Sulawesi supported local economic growth through employment, regional revenue, and downstream activities such as processing and logistics. BPS-based analyses also indicate that plantation by-products have potential for integrated agricultural systems, including livestock development, which can enhance resource efficiency and rural livelihoods [14]-[16].

RESEARCH METHODS

Materials

The materials used in this study were oil asphalt, coarse aggregate, fine aggregate, filler ash from empty oil palm bunches.

Equipment

1. Aggregate inspection test equipment:
2. One set of sieves (Sieve Analysis), Aggregate wear test equipment (Los Angeles Tests Machine) Specific gravity test equipment (pycnometer, scales, heater) Mold, Pumper, Ejector, Soaking tank (water bath)
3. Marshall and Cantambro test equipment
4. SEM-EDS test equipment

Working Steps

This step is an experimental laboratory study in the manufacture of hollow asphalt mixtures using empty oil palm bunches as follows:

Palm Oil Fiber Ash Processing

The following are the stages of palm oil fiber ash processing:

1. Collection of empty palm oil fruit bunch waste (Fiber)
2. Palm oil fiber is taken directly from the TBS (Fresh Fruit Bunch) transportation location in Central Mamuju Regency, West Sulawesi.
3. Drying of empty palm oil fruit bunch fiber
4. The palm oil waste fiber obtained is dried in the sun for about 1-2 days the next day until the palm oil fiber is dry.
5. Burning palm oil fiber
6. The process of burning palm fiber is carried out by burning it using a gas torch in a barrel and stirring it using iron or wood. This process aims to obtain palm oil fiber ash.
7. Filtering palm oil fiber ash
8. The ash from the burning is filtered using a filter according to REAM specifications. The purpose of this filtering is so that the palm oil fiber ash has a uniform level of fineness (retained by sieve No. 200).

Preparation of test objects using the following steps:

1. Prepare aggregates according to the composition of the specified mixture variations.
2. Heat the aggregates including the palm fiber ash filler variants with variants of 0%, 2.5%, 5%, and 7.5% to a temperature of 160○C, then add oil asphalt
3. After that, the mixture is stored until it reaches a temperature of 90○C to be compacted.
4. After that, it is carried out with a number of impacts of 2x50

RESULTS AND DISCUSSION

Analysis of SEM and EDS Test Results

SEM (Scanning Electron Microscope) and EDS (Energy Dispersive X-Ray) tests were carried out in the Microstructure laboratory of the Faculty of Engineering, UMI. SEM (Scanning Electron Microscope) testing in this study aims to see a clearer depiction of the layer structure with a larger magnification scale. In addition, EDS can also determine what elements are located, especially in

the area of burning ash from empty oil palm bunches and hollow asphalt with a mixture of empty oil palm bunches.

Analysis of SEM and EDS Test Results for Hollow Asphalt with a Mixture of Empty Oil Palm Bunch Waste.

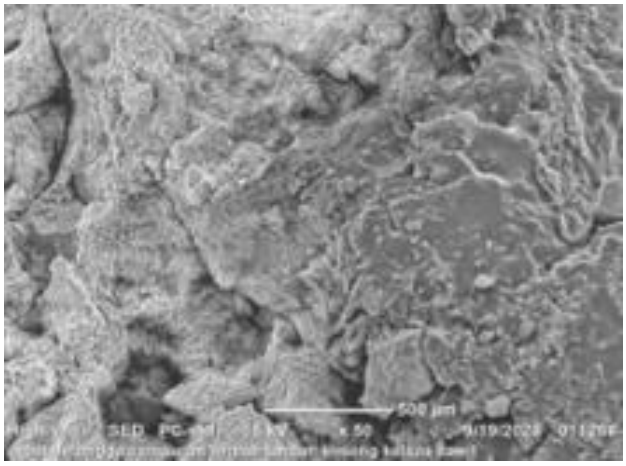

Figure 1. SEM morphology of hollow asphalt mixed with empty oil palm bunch waste, magnification 50 times Source: Personal Data, Muslika, 2024

EDS Analysis of Ash from Burning Empty Oil Palm Bunch Waste

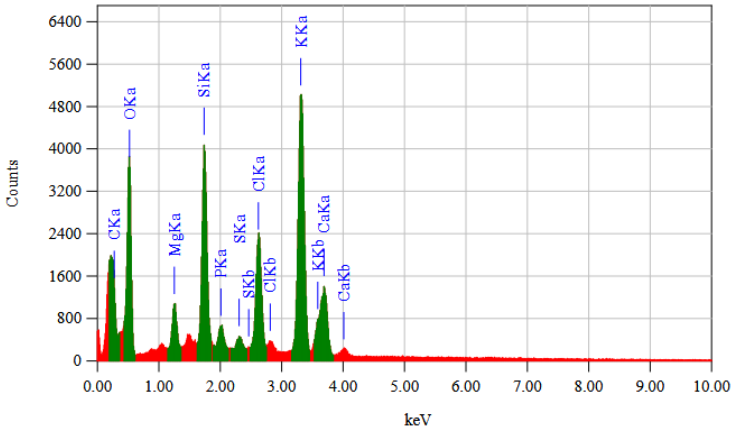

Figure 2. Spectrum of EDS test results of a sample of ash from burning empty oil palm bunches Source: Personal Data, Muslika, 2024

The spectrum of EDS test results of a sample of ash from burning empty oil palm bunches is shown in Figure 2 above, containing the following 9 chemical elements. It appears that the element with the highest atomic value is K (Potassium).

Table 1. Description of Energy (E_C) Minimum Emission Voltage, percentage of mass, atoms, and moles of each element

No	Element	Ec Minimum Emission Voltage (keV)	Mass %	Atom %	Mole %	Compound
1	C K	0.277	1.28	3.19	5.34	C
2	O K	0.525	12.54	23.51	-	-
3	Mg K	1.253	2.77	3.42	5.71	MgO
4	Si K	1.739	14.25	15.22	25.43	SiO2

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No	Element	Ec Minimum Emission Voltage (keV)	Mass %	Atom %	Mole %	Compound
5	P K	2.013	2.30	2.23	1.86	P2O5
6	S K	2.307	1.32	1.24	2.07	SO3
7	Cl K	2.621	14.01	11.86	19.81	Cl
8	K K	3.312	40.47	31.06	25.95	K2O
9	Ca K	3.690	11.05	8.28	13.83	CaO
Total		**17.737**	**100**	**100**	**100**	

Source: Personal Data, Muslika, 2024

Table 2. Electron shell letters

Description	K	Electron shell letters (have principal quantum number n = 1)
	C	Carbon
	O	Oxygen
	Mg	Magnesium
	Si	Silicon
	P	Phosphorus
	S	Sulphur
	Cl	Chlorine
	K	Potassium
	Ca	Calcium

Source: Personal Data, Muslika, 2024

SEM-EDS Analysis of Hollow Asphalt Mixture of Empty Oil Palm Bunch Waste

Scanning Electron Microscope (SEM) Characteristics

The results of SEM characteristics of hollow asphalt samples using empty oil palm bunch waste ash are shown with different scale bars of 5 µm (5000x magnification) for image 3a, and 10 µm (2000x magnification) for image 3b below.

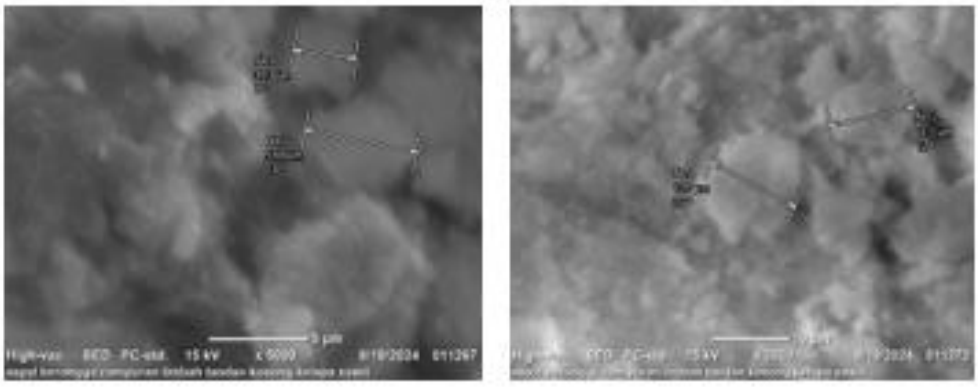

Figure 3. SEM photo at 2000x magnification, b) SEM photo at 5000x magnification Source: Personal Data, Muslika, 2024

The morphological condition of the sample at 2000x magnification shows a dense grain condition with the largest size of 12.0 µm and the smallest 11.1 µm with a few voids. While at 5000x magnification there are wider voids and the grains are not too dense where the largest is 5.69 µm and the smallest is 3.11 µm.

Energy Dispersive X-ray Spectroscopy (EDS) Characteristics

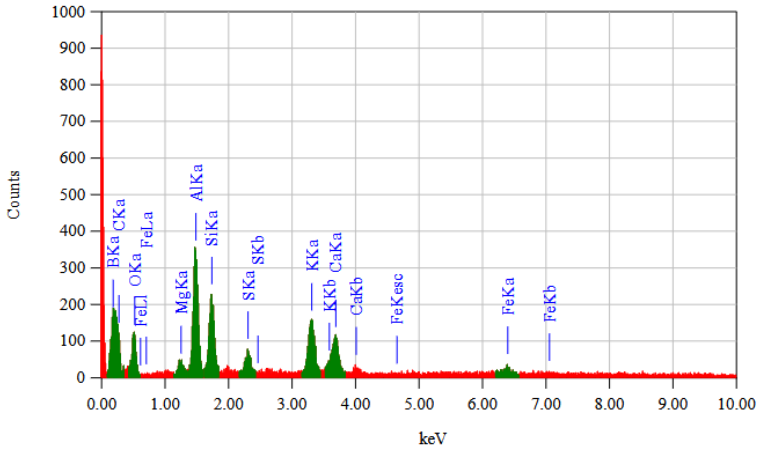

Figure 4. Spectrum of EDS test results of hollow asphalt samples from ash from burning empty oil palm bunches Source: Personal Data, Muslika, 2024

Table 3. Description of Energy (E_C) Minimum Emission Voltage, mass percentage, atoms, and moles of each element

No	Element	Ec Minimum Emission Voltage (keV)	Mass %	Atom %	Mole %	Compound
1	B K	0.183	43.68	66.55	59.06	B2O3
2	C K	0.277	3.77	5.17	9.17	C
3	O K	0.525	3.91	4.03	-	-
4	Mg K	1.253	1.08	0.73	1.30	MgO
5	Al K	1.486	13.02	7.95	7.06	Al2O3
6	Si K	1.739	7.60	4.46	7.91	SiO2
7	S K	2.307	3.24	1.67	2.96	SO3
8	K K	3.312	11.31	4.76	4.23	K2O
9	Ca K	3.690	8.88	3.65	6.48	CaO
10	Fe K	6.398	3.50	1.03	1.83	FeO
Total		**21.170**	**100**	**100**	**100**	

Source: Personal Data, Muslika, 2024

Table 4. Electron shell letters

Description	K	Electron shell letters (have principal quantum number n = 1)
	B	Boron
	C	Carbon
	O	Oxygen
	Mg	Magnesium
	Al	Aluminium
	Si	Silicon
	S	Sulphur
	K	Potassium
	Ca	Calcium

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Description	K	Electron shell letters (have principal quantum number n = 1)
	Fe	Iron

Source: Personal Data, Muslika, 2024

From the characteristics results, it is known that the elements contained in the hollow asphalt sample of a mixture of ash from burning empty oil palm bunches with the highest compound composition are Boron elements of 66.55% and the formation of new elements, namely Iron (Fe) with a percentage based on atoms of 1.03%, Aluminum (Al) of 1.75%.

Characteristic Results of Empty Oil Palm Bunch Waste Ash Before and After Mixing with Asphalt

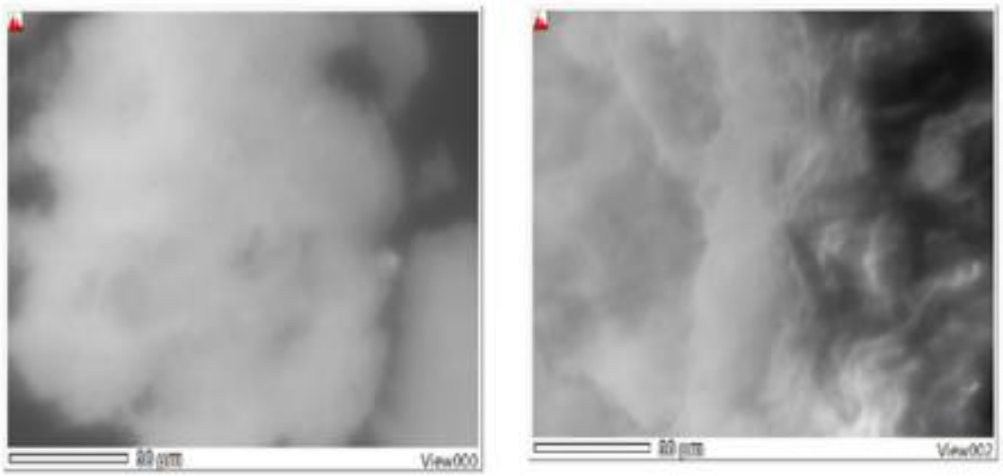

Figure 4. SEM photo magnification 3000x, b) SEM photo magnification 3000x Source: Personal Data, Muslika, 2024

CONCLUSION

The results of the SEM test show that the solid granules with voids that close each other with varying sizes. This is in line with the stability value obtained from the marshall test. Which increased due to the interlocking of the granules are interlocking. Meanwhile, from the results of the EDS test, the chemical element composition is known that the elements contained in the hollow asphalt sample of a mixture of ash from burning empty oil palm bunches with the highest compound composition are Boron elements of 66.55%, in contrast to the chemical composition test for ash from burning empty oil palm bunches, the highest compound composition based on the percentage of atoms is Potassium (K) of 31.6%.

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