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Initial Study on The Prospect of Solid Oil Waste Utilization From X Field as A Basic Material for Road Asphalt Mixing with Marshall Test

Erdila Indriani[1], Purnomosidi[1], Rizky Martha[2] and Bryan Ginting[2]

[1]Department of Oil and Gas Production Engineering, Politeknik Energi dan Mineral Akamigas
Gajah Mada Street Karangboyo, Cepu sub-district, Blora district, Central Java, 58315

[2]PT Pertamina EP Cepu
Gajah Mada Street Karangboyo, Cepu sub-district, Blora district, Central Java, 58315

Corresponding author: purnomosidi@esdm.go.id

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ABSTRACT - The upstream oil and gas industry in the production sector is made up of numerous lifting activities, carried out in wells, as well as storage and sales tanks. Preliminary research has been conducted on the process of gathering systems from each point of the production facility unit to determine the pressure loss, blockage or leakage problems. The findings showed that oil spill points due to the accumulation of crude spills mixed with other sediments was approximately 2043 m3 per week. B3 waste disposal is often a burden for companies because it is expensive without revenue value, while solid waste has economic value and can be reused. Therefore, this research aimed to evaluate the use of solid waste containing 48.01% Total Petroleum Hydrocarbons (TPH), including mineral and metal sediments, namely XRD, XRF and AAS tests as basic materials for road asphalt. The result showed that the use of solid waste with a density specification of 0.92 and a Pour Point of 1700 C as the basic material for making road asphalt mixed with aggregate achieved an initial setting time of less than 5 minutes and Compressive Strength of 0.25 MPa less than the 2 MPa standard value at R20. In conclusion, the Asphalt Resin Paraffinic Sediment obtained from solid waste was less than 10% and could not be used for road asphalt hardening, hence the need to add commercial asphalt and other additives.

Keywords: oil-solid waste, ARPS, marshall test, road asphalt.

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INTRODUCTION

Pertamina EP Field, characterized by relatively light (> 40 deg API) crude oil type, with high paraffin content is located in the Cepu Block, Blora, Central Java. However, the crude oil type found in some wells tends to contain paraffin. The production process ensured flows into the main collection station (SPU), where there is contact with others from various wells.

The PT Pertamina EP Field Cepu, produced solid oil waste, assumed to be B3 which accumulates at the bottom of the tank. This was detected during the cleaning of pipes or transportation lines, as well as the accumulated leaks at several points namely separators, transfer pumps, and tanks. Depositions of scale in long-term will disrupt the production process by blocking the fluid moving through the well and pipeline(Nuraini & L. Erwansyah 2018).

Based on Government Regulation Nos. 18 of 1999 and 85 of 1999 concerning the Management of Hazardous and Toxic Materials (B3), solid oil waste was included in the list with the code D220. The largest content was in the form of petroleum hydrocarbons (PT Pertamina 2001) and heavy metals (Prasetya et al. 2006; Budiarjo 2007) as example biodegradation od soil contaminated by crude oil (Sari. C.N & Lubnah. L 2018) processed through a cement-based stabilization or solidification procedure (Karamalidis & Voudrais 2007).

Stabilization or solidification limits the movement of elements and compounds by forming a monolithic mass bond with a robust structure (Spence & Shi 2006). The main mechanism in the binding of heavy metals by cement was realized through the following processes adsorption, absorption, precipitation, ion exchange, macro, and micro encapsulation, including complex formation (Abbassa et al. 2010). Meanwhile, to increase the benefit value, solid oil waste tended to be processed into alternative fuels, building materials and road coatings (Damanhuri & Adrismar 2001). This research applied solid waste from the X field as a basic material for asphalt production used in road construction.

The formulated research problem focused on how to determine the feasibility of solid oil waste as a substitute for asphalt. This also included how to produce asphalt aggregate mixture using solid waste as a base material. The research aided the use of solid oil waste as a substitute for asphalt to reduce the operational costs of waste handling. It also helped in improving the economy because waste can be reused, due to the selling value. Additionally, the research served as a reference for processing solid oil waste into a basic material for road asphalt.

METHODOLOGY

Sludge is a type of muddy waste produced from a mixture of crude oil and materials settled at the bottom of the tank. This waste is characterized by the semi-solid nature, consisting of three phases and several components, containing 20-90% water, 5-40% oil, and approximately 5-35% solids.

The disposal of this solid oil waste, also known as B3, is expensive. This waste has paste-like properties at room temperature, and a high melting point when liquefied. In addition, after the liquefaction process, the waste immediately solidifies at a fairly high temperature (>1500C). During the light phase of the evaporation process, a change was detected in mass. The hardening effect that occurred after the melting process had slight resemblance to asphalt. Therefore, solid waste oil can be used as a substitute for asphalt.

The feasibility testing of the waste was performed using the Marshall Method, proposed by Bruce Marshall. Furthermore, the method had been standardized by ASTM and AASHTO through several modifications, including ASTM D 1559-76 and AASHTO T-245-90. It is useful for testing the stability and flow of asphalt mixtures as well as analyzing the density and porosity of the solid mixtures formed. The Marshall Method served as a reference for determining the feasibility of solid oil waste as a substitute for asphalt used in road construction.

The test focused on the compressive strength of the mixture comprising solid oil waste and aggregate. Moreover, compressive strength depicts the strength of the mixture when given a load. After testing, the maximum load suspended by the mixture can be determined.

RESULTS AND DISCUSSION

Waste oil preparation

Solid waste oil

Solid waste accumulates from leaks in the X-field transfer pump, and separator. The waste is characterized by a black colour, has a paste-like shape at room temperature. It also feels rough and sandy with a strong odour typical of crude oil. Laboratory measurements were carried out to determine the sample density and Pour Point values of 0.92 Kg / m3 and 1700C, respectively.

Table 1 shows the result of the mineral composition test carried out using X-ray diffraction with a Rigaku 9 kW diffractometer and generator settings at 100 mA and 40 kV. In addition, the results showed that 49% of the solid oil waste constituted carbonate material, and the remaining 51% was an accumulation of quartz, plagioclase, chromite, and goethite. The absence of clay mineral material depicted that the solid waste was a homogeneous mixture of oil and sediment.

Table 1
Mineral composition analysis of solid waste

No	Sample Id	Clay Minerals (%)				Carbonate Minerals (%)			Other Minerals (%)						Total (%)			Remarks
		Smectite	Illite-smectite	Illite	Kaolinite	Calcite	Dolomite	Siderite	Quartz	Potash Feldspar	Plagioclase	Chromite	Geothilite	Pyrite	Clay	Cabonate	Other	
1	PEM AkaMigas	-	-	-	-	14	-	35	5	-	10	18	18	-	0	49	51	

Table 2
Results of metal content composition analysis of solid oil waste

Identity	Determination	Results	Unit	Methods
	Sluge			
	TPH	48,1	%	EPA 9071 B
	TCLP			
	Ba	2,2531	Mg/L	AAS
453/23	Cd	Nil	Mg/L	AAS
(202311174)	Cr	Nil	Mg/L	XRF
Sludge	Cu	0,0187	Mg/L	AAS
	Pb	0,3832	Mg/L	AAS
	Mo	Nil	Mg/L	AAS
	Ni	Nil	Mg/L	AAS
	Ag	Nil	Mg/L	AAS
	Zn	0,1357	Mg/L	AAS

In Table 2, the results of testing the metal content were realized using the EPA 9071 B. This method was adopted to determine the percentage of oil content (Total Petroleum Hydrocarbons or TPH), while XRF and AAS tools defined the type and amount of metal contained. The results of the test provided valuable information that TPH was 48.10%, with the highest metal content being Barium, approximately 2.2531 mg/L, followed by others with relatively small amounts of copper 0.0187 mg/L, lead 0.3832 mg/L, and zinc 0.1357 mg/L.

The research served as a reference, with the oil realized from the field explored based on certain characteristics. This included specific gravity of 0,8530, ^{o}API of 34,4, Kinematic viscosities of (100 ^{o}F) 5,71Cs, and (120 ^{o}F) 3,64, Cs, Pour point of 80 ^{o}F, Flashpoint of 35 ^{o}F Water content, % by volume of 0.18, Sulfur content, of 0,231, Wax content weight % of 14,4, Asphalt content weight % of 0.08, and total acid % KOH/gram of 0,084.

Based on the results obtained, this oil was characterized as Paraffinic with a high wax content. The API value of 34 ^{o}API also led to the classification in the medium category. The main force of the characteristic test was the assessment of asphalt content, determined to be less than 10%. This depicted whether the solid waste would have similar specifications as the oil tested. The high and low asphalt content certainly affected the concentration of heavy fractions bonding the sediment aggregates.

The results of testing the metal content of solid waste were realized using the EPA 9071 B method. This was aimed to determine the percentage of oil content, while XRF and AAS tools were used to define the type and amount of metal contained. The results provided information showed that TPH was 48.10%, with the highest metal content being 2.2531 mg/L of Barium, and others in relatively small amounts of copper 0.0187 mg/L, lead 0.3832 mg/L and zinc 0.1357 mg/L.

In accordance with the characteristics of oil from X field, it was deduced that Paraffinic oil had a high wax content. The API value of 34 ^{o}API also led to the classification in the medium category. The main focus for this characteristic test was the assessment of asphalt content, constituting less than 10%. This determined whether the solid waste would have the same specifications as the oil tested. The high and low asphalt content certainly affected the concentration of heavy fractions bonding the sediment aggregates.

Aggregate

The aggregates used in this research consisted of two categories. The first category, namely samples A and B, had aggregate grain sizes within 0.85 mm to 2 mm. Meanwhile, mixed samples one, two, and three comprised aggregate sizes within 0.1 mm to 1 mm. The size distribution used is rock diameter between 0.1- and 1 mm. Measurements were carried out using Sieve Shaker Analysis with 1000 grams of testing samples.

Figure 1 provides information on the size distribution of the aggregates used, with the rock diameter being between 0.1- and 1-mm. Measurements were carried out using Sieve Shaker Analysis with 1000 grams of testing samples. The experiment was conducted according to the Marshall method using the following standard RSNI M-01-2003. This referred to the General Specifications of Bina Marga 2010 revision 3 and SNI 06-2484-1991.

The result of molding a mixture of aggregate and solid waste without additives is shown in Figure 2. Samples A and B are mixtures with 30% solid waste and the rest aggregate. While one, two, and three are mixtures with 50% solid waste and the rest aggregate.

The experiment was conducted according to the Marshall method using the standard RSNI M-01-2003, referring to the General Specifications of Bina Marga 2010 revision 3 and SNI 06-2484-19. This resulted in the molding of a mixture of aggregate and solid waste without any additives. Samples A and B are mixtures with 30% solid waste and the rest aggregate. While samples one, two, and three are mixtures with 50% solid waste and the rest aggregat.

Table 3 is a recapitulation of the setting time results for all mix scenarios where information obtained passed the hardening setting time test with a reference time of less than five minutes only for samples A and B using the ASTM C187 method. Each scenario was tested thrice, therefore the results

Table 3
Compressive strength and initial setting time values for various experimental designs

	Compressive Strength (Psi)	Setting Time	Thickness (mm)
50%(1)	37	<20 mnt	57 mm
50%(2)	37	<20 mnt	48 mm
50%(3)	36,5	<20 mnt	36 mm
30%(A)	33	<5 mnt	42 mm
30%(B)	33	<5 mnt	48 mm

listed in the table comprised the average test value.

Based on the table the results of the setting time test for all mix scenarios where information obtained passed the hardening setting time test with a reference time of less than five minutes only for samples A and B using the ASTM C187 method. Each scenario was tested thrice, therefore the results

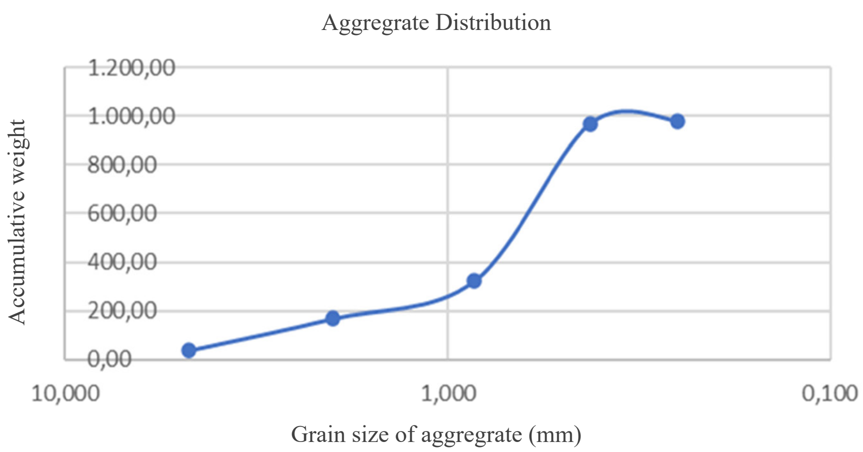

Figure 1
Size distribution of aggregate sand

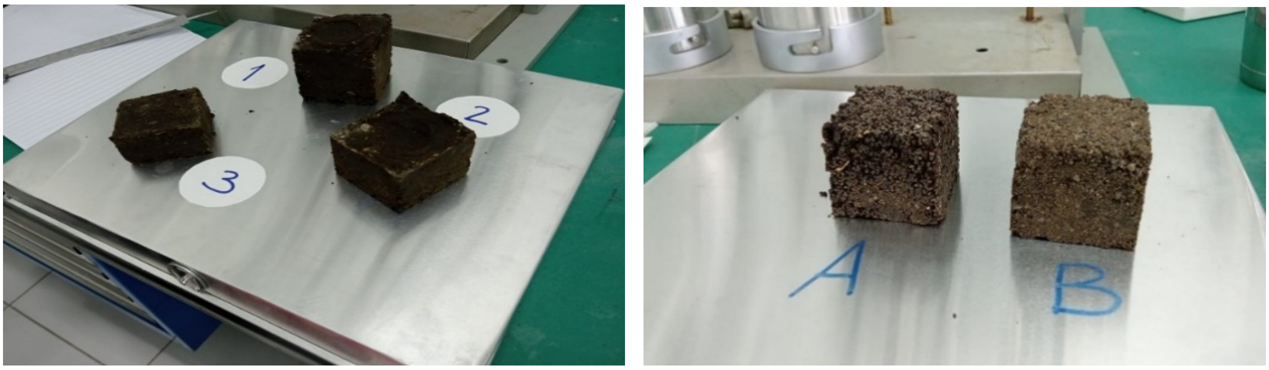

Figure 2
Molding results of aggregate and solid waste mixtures

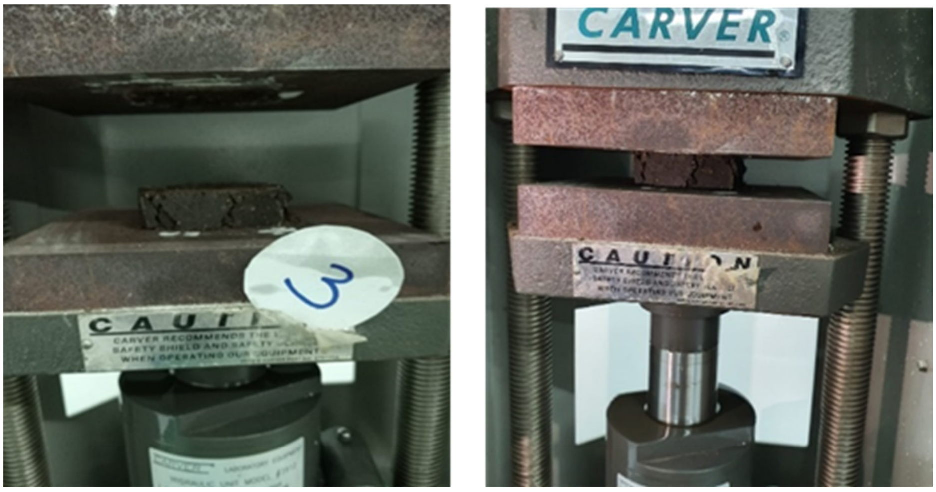

Figure 3
Compressive strength testing with hydraulic presses

listed in the table were the average test value.

The table also contained a recapitulation of the compressive strength values of each scenario within the setting time of more than 24 hours, including soaking activities according to the Marshall method. This resulted in compressive strength values of 33 Psi to 37 Psi or from 0.227 Mpa to 0.255 Mpa. Furthermore, the sample loading activity with hydraulic presses are shown in Figure 5.

Based on the ST RK 1225-2003 standard for Type B, Brand III, IV-V for roads with uphill schemes, compressive strength greater than 2 Mpa was required for R20. The maximum compressive strength obtained from the experiment was 0.255 Mpa. This is in line with the data of X oil as a reference for asphalt content of less than 1%, resulting in the function of heavy fraction that can bond the non-existent sediment aggregate.

The results obtained were at the initial stage because further research is required in accordance with the hypothesis that solid waste served as a base material for producing asphalt without a particular specification. The addition of solid waste as a partial replacement for asphalt reduced the quality of the mixture. The initial and final setting time values for the 30% and 40% mixtures were greater than five minutes. The VMA (Voids in aggregate minerals) value was presumably low, as evidenced by the easy change in shape, appearing spongier. Therefore, between aggregate grains, there were lots of empty spaces filled by paraffinic waste that easily changes or is unstable to loading.

Marshall Testing KAO Conditions After obtaining the KAO value of each mixture, and the optimum asphalt content. Moreover, there are two types of testing KAO conditions, namely using standard Marshall by soaking at room temperature for 24 hours, followed by soaking at 60oC for ± 30 minutes and Marshall durability testing with soaking performed at 60oC for 24 hours. Both tests aimed to determine the residual strength index (IKS) or stability of the asphalt mixture when soaked for 24 hours at 60oC. The results of the compressive strength test are shown in Table 3. The general specification of Bina Marga 2010 revision 3 proved the residual Marshall stability was 90% of the initial value. The hydraulic press test showed that the results of the asphalt mixture with 30% and 50% variations were less than the 90% standard or physically destroyed completely with only 37 Psi pressure as shown in Figure 5.

CONCLUSION

In conclusion, laboratory measurements produced solid waste characteristics with sample density and Pour Point values of 0.92 Kg / m3 and 1700C, respectively. These characteristics comprised mineral content of 49% carbonate and 51% constituting an accumulation of quartz, plagioclase, chromite, and goethite. The TPH content was 48.10%, with the highest metal content being 2.2531 mg/L of Barium, and relatively small quantities of copper 0.0187 mg/L, lead 0.3832 mg/L and zinc 0.1357 mg/L.

The results of the test in compressive strength values and general specifications of Bina marga 2010 revision 3 showed that the residual Marshall stability value was 90% of the initial stability value. The hydraulic press test proved that the asphalt mixture with 30% and 50% variations were less than the 90% standard or physically destroyed completely with only 37 Psi pressure. The compressive strength value was 37 Psi or 0.255 Mpa, less than the Bina Marga standard specified for type B roads, which needed to be greater than 2 Mpa.

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GLOSSARY OF TERMS

Symbol	Definition	Unit
AASHTO	American Association of state Highway and Transportation Officials	
ASTM	American Society for Testing and Materials	
API Gravity	A specific gravity scale developed by the American Petroleum Institute (API) for measuring The relative density of various petroleum liquids, expressed in degrees.	°API Degree
KAO	Kadar Aspal Optimum	%
TPH	Total Petroleum Hydrocarbon	
VMA	Void in Mineral Aggregate	%

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