

Performance of asphalt wearing course against the immersion effect of tidal flood (rob) with added materials polyethylene and fine aggregate slag

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Abstract. Rob or tide water is a flood of seawater or rising sea level caused by high tide inundating the land. Heavy traffic and tidal immersion on main roads result in permanent deformation require quality asphalt that is resistant to tidal immersion and traffic loads. The use of a combination of LDPE and aggregate slag is an unprecedented update. Polyethylene (PE) plastic waste provides water resistance therefore the combination can be a new Job Mix Formula that is able to withstand tidal immersion (rob) allowing it to be used in the construction of road structures (Flexible Pavement). The duration of immersion is 7 days, 14 days and 21 days and the soaking method consists of immerse with a continuous pattern and soaking with a periodic / cyclic pattern (intermittent). The best composition for Asphalt Concrete Wearing Course obtained in continuous soaking was 50% Slag aggregate and 6% LDPE while for intermittent soaking it was 0% and 50% Slag aggregate with 6% and 8% LDPE.

1 Introduction

Rob or tide water is a flood of seawater or rising sea level caused by high tide inundating land [1]. Tidal water makes the asphalt's adhesion towards the aggregate weaker so leading to deformation when the road pavement is passed. Tidal water also comes from the sea which contains high levels of acidity, chloride and sulfate levels that can weaken the adhesion ability of asphalt to maintain the bonds between asphalt either cohesion or adhesion [2]. A way to overcome tidal water immersion is to modify the asphalt using an added material, namely polymer [3].

Asphalt wearing course with polyethylene additives and slag fine aggregates is a mixture of asphalt materials where plastomeric polymers are added, namely Low Density Polyethylene (LDPE) and steel slag aggregates with the aim of gaining strength against tidal immersion and traffic loads with the main axle load so that this asphalt has durability and good stability up to 21 days of immersion. The use of a combination of LDPE and aggregate slag is an unprecedented update. Polyethylene (PE) plastic waste provides water resistance therefore the combination can be a new Job Mix Formula that is able to withstand tidal immersion (rob) allowing it to be used in the construction of road structures (Flexible Pavement).

Heavy traffic and tidal immersion on main roads result in permanent deformation it requires quality asphalt that is resistant to tidal immersion and traffic loads. Similar problems can also be encountered even on straight roads due to slowing speed and heavy

truckloads and trailer loads. The construction of asphalt that is resistant to tidal immersion in accordance with the specifications is required. Bitumen and filler are mixed with crackle plastic bags to strengthen the stability value and resistance to water immersion as plastic will envelop the aggregate thus strengthening the immersion to bind together in unity. Steel slag aggregates also contribute an important role in the mixing of asphalt concrete in order to make the asphalt concrete able to withstand traffic loads and tidal flood disasters that occur on the main road.

In terms of optimal asphalt content, mixed steel slag aggregate has a higher value than conventional mixture. Due to the higher porosity level possessed by steel slag aggregates. The resilient modulus results show that the steel slag mix has a higher value compared to the conventional aggregate mix. In addition, temperature also affects the resilient modulus results [4].

This research is a renewal of the Modified Asphalt Wearing Course which was previously unable to be submerged in tidal floods for a long time. With just a matter of hours this asphalt wearing course loses stability due to being soaked by tidal floods, so an asphalt wearing course is needed that has stability and durability that lasts in tidal water for a long time.

Research using a combination of LDPE and Slag aggregate is a novelty that didn't existed before because PE plastic waste provides resistance to water so that the combination can be a new Job Mix Formula that is able to withstand tidal immersion (tidal) so that it can be used in the construction of road structures (Flexible Pavement).

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2 Methods

The research method in this study uses the experimental research method. The research was conducted at the Road Transportation Laboratory of Islamic University Sultan Agung Semarang. In this study, experiments were carried out in the laboratory by providing treatment in the form of immersion of the modified asphalt concrete wearing course. The modified asphalt concrete wearing course was immersed in laboratory standard water, tidal water, and water with varying chloride (Cl) content. The duration of immersion are 7 days, 14 days, and 21 days and the immerse method consists of immersion with a continuous pattern and immerse with a periodic/cyclic pattern (intermittent). The next section will explain about the materials used in this research.

2.1 Asphalt

The asphalt coating used in this study is the type commonly used in road construction in Indonesia, namely JAP Polymer Asphalt – 57 (Jaya Trade Polymer Asphalt). JAP 57 is the result of asphalt modification obtained by combining conventional asphalt with DuPont Elvaloy (elastomer). By using RET (Reactive Elastomer Terpolymer) technology, there is no separation or precipitation between asphalt and polymer, because the reaction takes place chemically. The tests carried out for this polymer asphalt are 4 parameters, which are penetration, ductility, flash point, and softening point. These parameters can represent the main characteristics of polymer asphalt to be applied as a mixture for flexible pavements. Asphalts test result is listed in Table 1 using a comparison based on road inspection specification No. 01/MN/BM/1976 Bina Marga.

Table 1. Asphalt JAP (Jaya Asphalt Polymer) 57 test

Types of Examinations	Unit	Specification of Asphalt JAP 57		Examination Results	Specifications
		Min	Max		
Penetration 25°C, 100 g, 5 seconds	0.1 mm	50	80	55.9	SNI-06-2456-1991
5°C Flaccid Point (Ring and Ball Test)	°C	54	-	56.65	SNI-06-2434-1991
Flash Point (Cleaveland Open Cup)	°C	232	-	351.5	SNI-06-2433-1991
Solubility in CCl ₄	%	99	-	99.93	SNI-06-2438-1991
Ductility	Cm	50	-	>150	SNI-06-2432-1991
Penetration after Losing Weight	%	54	-	61.90	SNI-06-2440-1991
Kinematic Viscosity temperature 135°C	Cst	-	3000	1365.5	AASHTO T316-13
RTFOT					
Losing Weight (RTFOT)	%	-	0.8	0.051	SNI-06-2440-1991
25°C penetration after RTFOT	%	54	-	61.90	SNI 2465; 2011
Ductility after RTFOT	Cm	50	-	110.33	SNI 06-2432-1991
Elastic Recovery after RTFOT	%	-	-	70	AASHTO T-301-98
DSR (RTFOT) Fail Temperature	°C	70	-	70.10	AASHTO T-315-12
PAV					
DSR PAV @5000 kPa Fail Temperature	°C	-	31	22.70	AASHTO T-315-12

2.2 Rob floodwaters

The tidal flood water used comes from tidal floods that occur around the Sayung Central Java tidal flood inundation. As a comparison is floodwaters from Jl. Barito East Semarang was used. Table 2 presents details of the examination of tidal and floodwater results.

Table 2. Results of rob and floodwater examination

Probe Parameters	Unit	Rob Water	Floodwaters
Suspended Solids (TSS)	mg/L	38	28
Dissolved Solids (TDS)	mg/L	1236	938
Chloride (Cl)	mg/L	9550	753
Sulphate (SO ₄)	mg/L	2000	599
Salt Content / Salinity	g/L	22,58	16,93
pH		7,15	6,95

2.3 Coarse aggregates

Coarse, fine, filler aggregates are obtained from the results of stone crusher at AMP (Asphalt Mixing Plant) PT Perwita Karya Sembung Batang Central Java.

2.4 Fine aggregates

The fine aggregate material as an object of research is the result of breaking and pounding slag chunks taken from the center of iron processing or metal refining in Batur Village, Ceper District, Klaten Regency with variations in the content of the fine aggregate slag is 100% fine aggregate slag, 100% fine aggregate crushed stone, and 50% fine aggregate slag plus 50% fine aggregate crushed stone.

In the coarse aggregate sieve analysis of Hot Bin II, III, IV, 100% of the aggregate passes the ½" sieve and is retained on the 3/8" or 9.52 mm sieve 100% of the time. For medium aggregate distribution, 100% of the total medium sieve analysis samples are aggregates that

pass the 3/8" sieve and are retained on the No. 4 or 4.76 mm sieve as much as 100%. For fine aggregates, it is distributed in each sieve and it shows at Fig. 1 and Table

3 the comparison of percentaged passed aggregate on the sieve number.

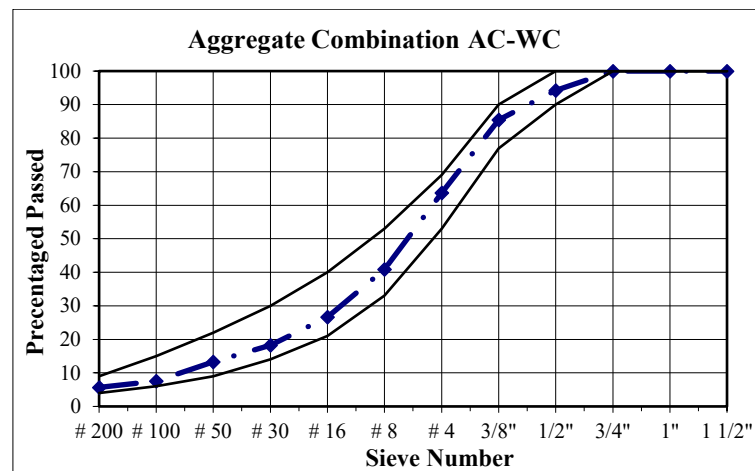


Fig. 1. Aggregate combination chart

Table 3. Aggregate combination

Sieve Number	Percentage Passed	Specifications	
	Combination Of Passes	Lower Limit	Upper Limit
# 200	4.7	4.0	9.0
# 100	7.6	6.0	15.0
# 50	13.2	9.0	22.0
# 30	18.2	14.0	30.0
# 16	26.7	21.0	40.0
# 8	40.9	33.0	53.0
# 4	63.7	53.0	69.0
3/8"	85.5	77.0	90.0
1/2"	94.3	90.0	100.0
3/4"	100.0	100.0	100.0
1"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0

2.5 Low density polyethylene

The polymer used is in the form of Polyethylene (PE) plastic waste (Fig. 2) with a Low-Density Polyethylene (LDPE) type as an asphalt substitute [3]. Low Density Polyethylene or LDPE is the most commonly used plastic material. Its physical character is very flexible and easy to apply to various surfaces. This type of polyethylene can be found in construction, protective tarpaulins, and coatings on agricultural lands. Plastic waste can be easily used as a modifier for bituminous concrete mixture because it is coated on top of the mixed aggregate and reduces porosity, moisture absorption and improves the binding property of the mixture [5].



Fig. 2. Polyethylene plastic waste

2.6 Sample Preparation and Research Process

The implementation of the research was conducted in several stages, including the preparation stage of research materials, determination of asphalt content, making test objects, immersion and testing stages in the laboratory. The planned asphalt is LDPE with levels of 0%, 2%, 4%, 6%, 8%, 10% and 18% while the aggregate content of crushed stone combination Slag with levels of 0%, 50% and 100% with two immersion methods, which are continuous and periodic immersion. Making test objects with an optimum asphalt content of 5.8% with LDPE levels of 0%, 2%, 4%, 6%, 8%, 10% and 18%. Each test object is 3 pieces so that the total test object is 414 test objects, the detail shows in Table 4.

Table 4. Test objects

Type	Immersion	Sum	Total
Variations in asphalt content (4; 4.5; 5; 5.5; 6)		3 pcs	15 pcs
LDPE levels (0%,2%, 4%, 6%,8%,10%,18%)		3 pcs	12 pcs
LDPE levels (0%,2%, 4%, 6%,8%,10%,18%) (0,50,100 slags) aged 7, 14 and 21 days	Continuous tides and floodwaters	3 pcs	189 pcs
LDPE levels (0%,2%, 4%, 6%,8%,10%,18%) (0,50,100 slags) aged 7, 14 and 21 days	Continuous tides and floodwaters	3 pcs	189 pcs
WTM (Slag 50% and LDPE 6%) combination		3 pcs	9 pcs
Total Of Test Items			414 pcs

The sample of the test material made was then carried out by Marshall to determine the optimum asphalt content with various immersion.

2.7 Marshall test

One of the methods used in evaluating the effect of water on asphalt pavement mixtures is the Marshall Immersion test in which the stability of the test object is

determined after one day of immersion in water at 60 °C [6]. Marshall testing is the most common laboratory method used to check the performance of hot mixes by obtaining the stability and fatigue values of plasticized mixtures by using Marshall tools [7]. For mixing purposes, aggregates and asphalt are heated at a temperature with asphalt viscosity values of 170 ± 20 centistokes (cst) and compacted at temperatures with a asphalt viscosity values of 280 ± 30 cst. The tool used for the compaction process is the Marshall Compaction Hammer.

Marshall immersion testing this test was made after obtaining Optimum Asphalt Content (OAC) [8]. From the Marshall test, parameters called Marshall Properties were obtained, which consisted of density, stability, flow, Marshall Quotient (MQ), percentage of void in the mixture (VIM), percentage of void filled with asphalt (VFA), and percentage of void in aggregate (VMA).

3 Results and discussion

The test carried out was the Marshall test to determine the stability of hard asphalt then continued with tidal and floodwater testing to compare the immersion that occurred. The following describes a further analysis of the modified mixture.

3.1 Tidal and floodwater testing

This Rob Water and Floodwater Testing was conducted by the PT Superintending Company of Indonesia (Persero) (hereinafter referred to as SUCOFINDO) is a State-Owned Enterprise built between the Government of the Republic of Indonesia and SGS, the largest inspection company in the world based in Geneva, Switzerland. SUCOFINDO has developed services in the business of inspection and audit, testing and analysis, certification, consulting, and training in agriculture, forestry, mining (oil and gas and non-oil and gas), construction, processing industry, marine, fisheries, government, transportation, informatics systems and renewable energy. This test is conducted with the purpose of determining the content of tidal water (more specifically) that may affect or decrease the characteristics of the asphalt concrete mixture used.

3.2 Results of continuous immersion of tide flood

The continuous tidal immersion was carried out with the varied aggregate mixes shown in the Table 5 and Fig. 3-4 with immersion durations of 7 days, 14 days, and 21 days.

Table 5. Results of continuous immersion of tide flood

Content (Aggregate 50%)	Void in Minerals (VIM)						
	0%	2%	4%	6%	8%	10%	18%
7 days	-0,65	-10,89	-5,6	3,57	-29,45	-28,58	-26,26
14 days	-1,03	-10,08	-14,75	3,18	-28,5	-28,58	-27,76
21 days	-1,17	-8,89	-30,11	3,04	-27,12	-28,46	-28,95

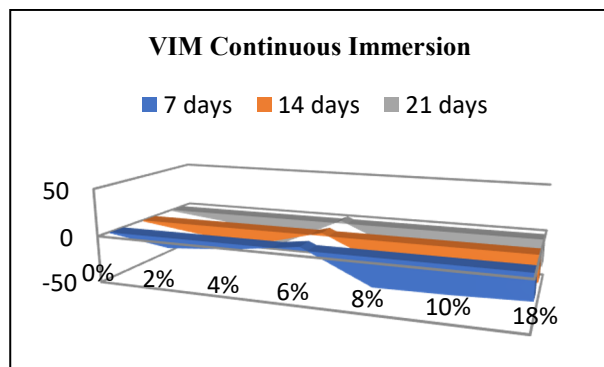


Fig. 3. Results of continuous immersion of tide water

The results of continuous immersion of the tide flood (rob) showed that VIM at LDPE levels of 6% was included in the requirements that are between 3-5%

while LDPE levels of 0%, 2%, 4%, 8%, 10% and 18% were excluded from the requirements (Table 6).

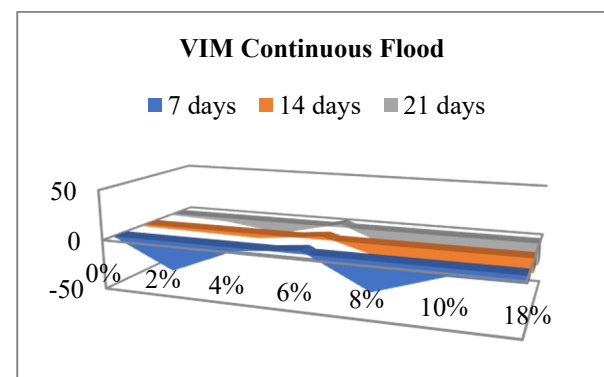


Fig. 4. Results of continuous immersion of floodwaters

Table 6. Results of continuous immersion of floodwaters

Content (Aggregate 50%)	VOID IN MINERALS (VIM)						
	0%	2%	4%	6%	8%	10%	18%
7 days	0,25	-29,38	-3,2	3,21	-29,38	-7,76	-7,25
14 days	-2,19	-3,05	-3,99	3,23	-14,86	-14,54	-14,01
21 days	-1,54	-3,76	-11,38	3,4	-21,99	-22,26	-22,13

The results of continuous immersion of floodwaters, it shows that VIM at LDPE levels of 6% was included in the requirements that are between 3-5% while LDPE

levels of 0%, 2%, 4%, 8%, 10% and 18% were excluded from the requirements.

3.3 Results of Periodic Immersion of Tide Flood

The periodic tidal water immersion was carried out with the varied aggregate mixes shown in the Table 7 and Fig.

5 with the immersion durations of 7 days, 14 days, and 21 days.

Table 7. Results Periodic Immersion of Tide Flood

Content (Aggregat 50%)	Void in Minerals (VIM)						
	0%	2%	4%	6%	8%	10%	18%
24 hours	-2,96	-2,25	-2,97	3,12	3,21	2,26	0,16
48 hours	-1,23	-2,15	-2,33	3,08	3,11	2,34	1,2
72 hours	-1,97	-1,94	-3,43	3,47	3,35	2,13	1,23

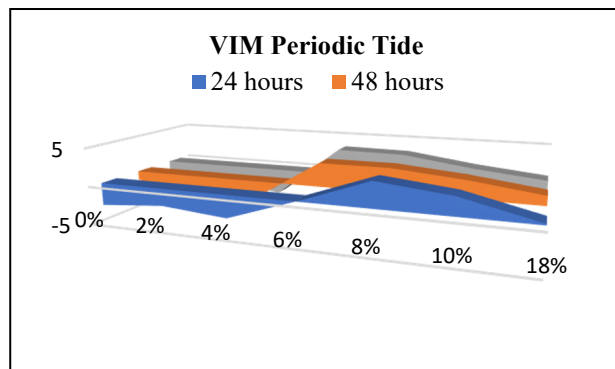


Fig. 5. Results of periodic immersion of tide water

The results of the periodic immersion of tide flood showed that VIM at LDPE levels of 6% and 8% was included in the requirements that are between 3-5% while LDPE levels of 0%, 2%, 4%, 10% and 18% were excluded from the requirements.

3.4 Results of Periodic Immersion of Floodwaters

The periodic flood water immersion was carried out with the varied aggregate mixes shown in the Table 8 and Fig. 6 with the immersion durations of 7 days, 14 days, and 21 days.

Table 8. Results of periodic immersion of floodwaters

Content (Aggregat 50%)	VOID IN MINERALS (VIM)						
	0%	2%	4%	6%	8%	10%	18%
24 hours	0,59	0,8	-0,28	3,08	3,08	0,14	0,16
48 hours	0,72	0,83	-0,44	3,08	3,11	0,01	0,04
72 hours	1,59	0,84	-0,37	3,05	3,12	0,06	0,01

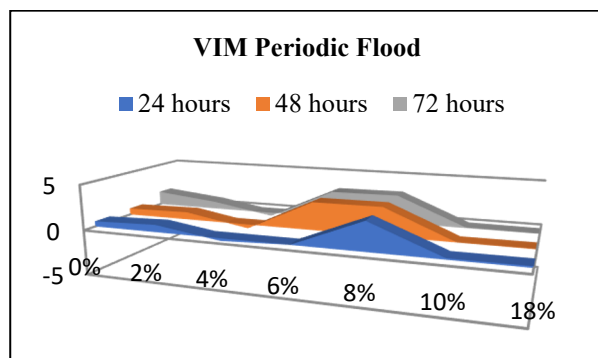


Fig. 6. Results of periodic immersion of floodwaters

The results of the periodic immersion of floodwaters showed that VIM at LDPE levels of 6% and 8% was included in the requirements that are between 3-5% while LDPE levels of 0%, 2%, 4%, 10% and 18% were excluded from the requirements.

(Rob) and also flood water for 7, 14, and 21 days that can be used on pavements is a combination of 50% Slag aggregate and 6% LDPE. Whereas for periodic immersion in tidal and flood water for 24, 48, and 72 hours, the combination of 0% and 50% Slag aggregate and 6% and 50% LDPE can be used in pavement. The best composition for Asphalt Concrete Wearing Course obtained in continuous immersion is 50% Slag aggregate and 6% LDPE while for periodic immersion is 0% and 50% Slag aggregate with 6% and 8% LDPE.

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4 Conclusion

Based on the research and data analysis of the performance of Asphalt Concrete Wearing Course mixtures using polyethylene additives and fine aggregate slag against the influence of tidal water immersion (ROB), it is concluded that the Job Mix Formula that can be used on modified Asphalt Concrete Wearing Course continuously submerged in tidal water

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