Journal of
Advanced Civil and Environmental Engineering
Vol.6, No.1, 2023, pp 24-32
ISSN: 2599-3356
DOI: http://dx.doi.org/10.30659/jacee.6.1.24-32

Performance of Asphalt Wearing Course Against The Immersion Effect Of Tide Water (Rob) With Added Materials Polyethylene And Fine Aggregate Slag

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(**Received:** 12th February 2023 ; **Revised:** 13th April 2023 ; **Accepted:** 17th May 2023)

Abstract: Rob or tide water is a flood of seawater or rising sea level caused by high tide inundating 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). Job Mix Formula that can be used on asphalt concrete wearing course modification is a combination of 50% Slag aggregate and 6% LDPE while asphalt concrete wearing course modification of 0% and 100% Slag Aggregate grades with LDPE 0%, 2%, 4%, 8%, 10% and 18% cannot be used as road pavement because it does not meet the requirements of Bina Marga technical specifications.

Keywords: p*ermanent deformation; immersion; tide; asphalt concrete wearing course.*

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 steel slag as an aggregate substitute to natural aggregates is considered a standard practice in many countries [4]. Waste plastic is a significant and growing environmental challenge and includes industrial plastics, plastic bags and plastic bottles [5]. 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 require 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. Bintumen 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 [6].

2. Methods

The research method in this study uses experiment 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 immerse 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 are listed in Table 1 using a comparison based on road inspection specification No. 01 / MN / BM / 1976 Bina Marga.

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

Types of Examinations	Unit	Specification of Asphalt JAP 57		Test 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 (Cleavelend Open Cup)	°C	232	-	351,5	SNI-06-2433-1991
Solubility in CCl4	%	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	AASTHO T-301-98
DSR (RTFOT) Fail Temperature	°C	70	-	70,10	AASTHO T-315-12
PAV					
DSR PAV @5000 kPa Fail Temperature	°C	-	31	22,70	AASTHO 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 (SO4)	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 fine aggregate slag is 100% fine aggregate slag, 100% fine aggregate crushed stone, and 50% fine aggregate slag plus 50% fine aggregate crushed stone.

2.5. Low Density Polyethylene

The polymer used is in the form of Polyethylene (PE) plastic waste 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 [7].

Fig. 1. 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 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.

Table 3. 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.

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 [8]. 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 [9]. 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) [10]. 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 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 Water

The results of continuous immersion of the tide water (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 in the requirements.

Table 4. Results of Continuous Immersion of Tide Water

Content	Void In Minerals (VIM)						
(Aggregat 50%)	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

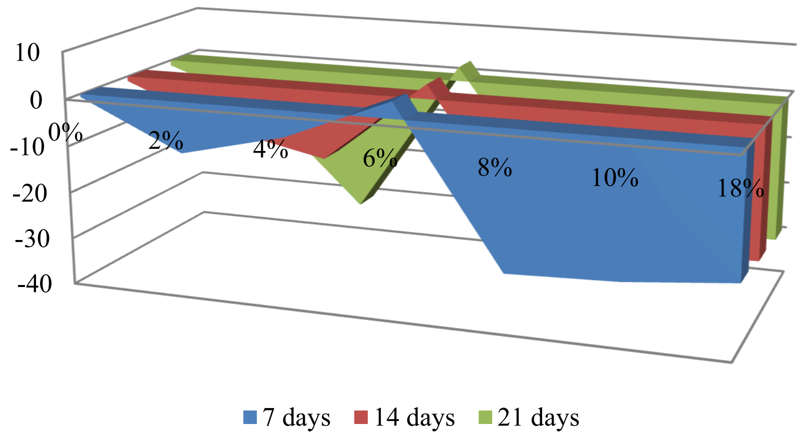

Fig. 2. Results of VIM Continuous Immersion of Tide Water

3.3. Results of Continuous Immersion of Floodwaters

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 in the requirements.

Table 5. Results of Continuous Immersion of Floodwaters

Content	Void In Minerals (VIM)						
(Aggregat 50%)	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

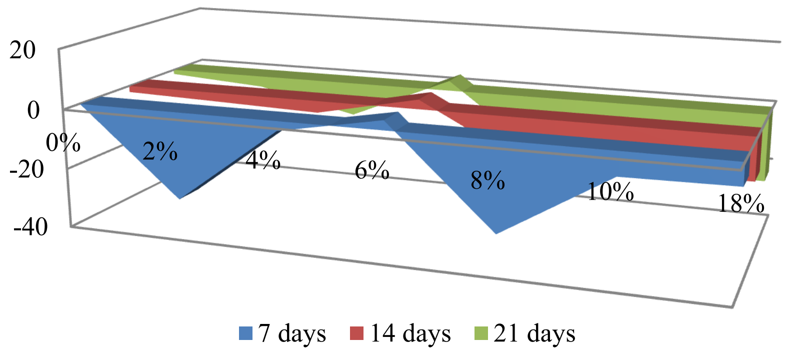

Fig. 3. Results of VIM Continuous Immersion of Floodwaters

3.4. Results of Periodic Immersion of Tide Water

The results of the periodic immersion of tide water 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 in the requirements.

Table 6. Results Periodic Immersion of Tide Water

Content	Void In Minerals (VIM)						
(Aggregat 50%)	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

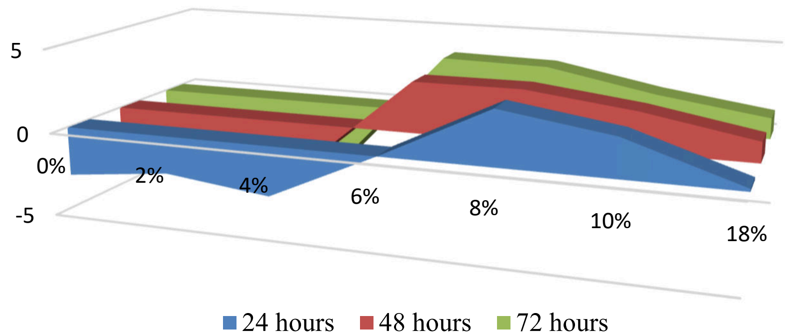

Fig. 4. Results of VIM Periodic Immersion of Tide Water

3.5. 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 in the requirements.

Table 7. Results of Periodic Immersion of Floodwaters

Content	Void In Minerals (VIM)						
(Aggregat 50%)	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

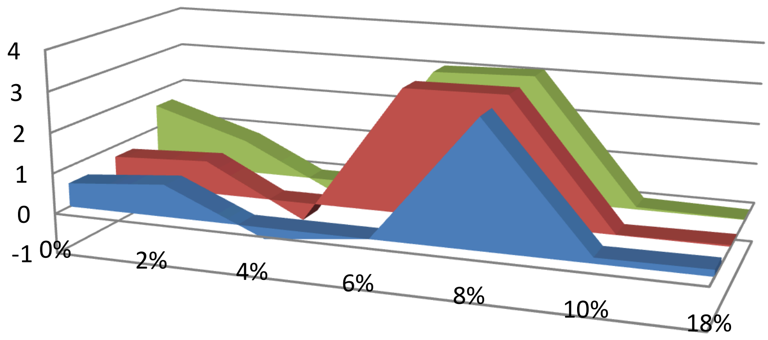

Fig. 5. Results of Periodic Immersion of Floodwaters

4. Conclusion

Based on the research and analysis performance of asphalt concrete wearing course mixture data using added material polyethylene and fine aggregate slag on the influence of tide water (ROB), the conclusion of the Job Mix Formula that can be used on the Asphalt Concrete Wearing Course modification immerse in tide water (Rob) at 7, 14, and 21 days old continuous immersion that can be used on road pavement is a combination of 50% Slag aggregate and 6% LDPE while asphalt concrete wearing course modification immerse by pairs at 7, 14, and 21 days old continuous immersion of 0% and 100% Slag aggregate content with 0% LDPE, 2%, 4%, 8%, 10% and 18% cannot be used as road pavement because they do not meet the technical specification requirements of Bina Marga in 2018 Revision 2 with air cavity values up to -87.09%.

References

[1] Patrisia, Y., & Murwantini, S. (2013). Influence of Ulin Wood Grain Usage as Fiber Material on Concrete Compressive and Tensile Strength. *BALANGA: Jurnal Pendidikan Teknologi Dan Kejuruan*, *1*(1), 11–20.

[2] Muammar, R., Saleh, S. M., & Yunus, Y. (2018). Durability of the wear-resistant Laston mixture (AC-WC) in substitution of low density polyethylene (LDPE) waste in a dry way against soaking cow dung. *Jurnal Teknik Sipil*, *1*(3), 689–700. (in Indonesian)

[3] Milad, A. A., Ali, A. S. B., & Yusoff, N. I. M. (2020). A review of the utilisation of recycled waste material as an alternative modifier in asphalt mixtures. *Civil Engineering Journal*, *6*, 42–60.

[4] Zumrawi, M. M. E., & Khalill, F. O. A. (2017). Experimental study of steel slag used as aggregate in asphalt mixture. *Am. J. Constr. Build. Mater*, *2*(1), 26–32.

[5] White, G., & Reid, G. (2018). Recycled waste plastic for extending and modifying asphalt binders. *8th Symposium on Pavement Surface Characteristics (SURF 2018), Brisbane, Queensland, Australia*, 2–4.

[6] Hainin, M. R., Yusoff, N. I. M., Mohammad Sabri, M. F., Abdul Aziz, M. A., Sahul Hameed, M. A., & Farooq Reshi, W. (2012). Steel slag as an aggregate replacement in Malaysian hot mix asphalt. *International Scholarly Research Notices*, *2012*.

[7] Mishra, B., & Mishra, R. S. (2015). A study on use of waste plastic materials in flexible pavements. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*(8), 6927–6935.

[8] Intari, D. E., Fathonah, W., & Kirana, F. W. (2018). Analysis of Lataston (HRS-WC) Mixture Characteristics due to High Tide Sea Water Intrusion with Starbit E-55 Polymer Modified Asphalt. *Fondasi: Jurnal Teknik Sipil*, *7*(2). (in Indonesian)

[9] Jamshidi, A., Kurumisawa, K., White, G., Nishizawa, T., Igarashi, T., Nawa, T., & Mao, J. (2019). State-of-the-art of interlocking concrete block pavement technology in Japan as a post-modern pavement. *Construction and Building Materials*, *200*, 713–755. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2018.11.286.

[10] Sumarjo, J., Santosa, A., & Purbowo, R. (2017). Design and Fabrication of Ultrasonic Non-Destructive Testing (NDT) Equipment using Microcontroller Method. *INFOMATEK: Jurnal Informatika, Manajemen Dan Teknologi*, *19*(2), 49–56.