Experimental Study on Effects of Flood Puddle to Durability of Asphaltic Concrete Containing *Refined Butonic Asphalt*

Nur ALI
Doctoral Student
Graduate School of Civil Engineering
Civil Engineering Department
Hasanuddin University
Jl. Perintis K, Km. 10, Makassar
90-145 Indonesia
Telp/Fax: +62-411-586-015
E-mail: nuralimti@gmail.com

Muhammad Wihardi TJARONGE
Professor
Material & Structural Eng. Laboratory
Civil Engineering Department
Hasanuddin University
Jl. Perintis K, Km. 10, Makassar
90-145 Indonesia
Telp/Fax: +62-411-586-015
E-mail: tjaronge@yahoo.co.jp

Lawalenna SAMANG
Professor
Geotechnical Engineering Laboratory
Civil Engineering Department
Hasanuddin University
Jl. Perintis K, Km. 10, Makassar
90-145 Indonesia
Telp/Fax: +62-411-586-015
E-mail: samang_l@yahoo.com

Muhammad Isran RAMLI
Associate Professor
Transportation Engineering Laboratory
Civil Engineering Department
Hasanuddin University
Jl. Perintis K, Km. 10, Makassar
90-145 Indonesia
Telp/Fax: +62-411-586-015
E-mail: muhisran@yahoo.com

Abstract: The purpose of this paper is to grasp effect of flood puddle to durability of asphalt concrete mixture on road pavement. In this regard, an experimental study was carried out by using *Modified Immersion* test in order to represent the flood phenomenon and *Marshall Immersion* test as reference. The experimental treated immersion test during 1, 3, 5, and 7 days to the two types of asphalt mixture, i.e. the mixture containing *Retona* additive and un-containing it. The research adopted three types of durability indexes to describe asphalt mixture durability, i.e. the retaining strength index (RSI), the first durability index (FDI), and the second durability index (SDI). The results show that *Modified Immersion* test gave good appearance to grasp deterioration of the mixtures durability due to flood puddle during some days. In further, the asphalt concrete mixtures still retained until seven days immersion, where the mixture containing *Retona* was more durable than the other mixture.

Key Words: *Durability, flood puddle, asphaltic concrete, Refined Butonic Asphalt.*

1. INTRODUCTION

Nowadays, flood as one type of disaster as impact of global warming and climate change have been deteriorating environmental quality of urban infrastructure in tropical countries. In particular, the disaster provides puddle phenomenon as a continuing waste to road pavement infrastructure. The phenomenon leads to effect to durability of the pavement especially for surface layer that containing bitumen and aggregate mixture. The major impact of the flood puddle is deterioration to the layer durability. It is caused of water infiltration into the asphalt pavement. The most serious consequence of the adverse action of water is the loss of adhesion between the aggregate and bitumen, commonly called as stripping, resulting in substantial reduction in the strength of the bituminous mixture (Siswosoebrotho *et al.*, 2003).

In order to grasp the adverse action of water, only a few scholars have been conducted research. In this regard, Siswosoebrotho *et al.* (2003) developed a cyclic water vapor test for durability assessment of bituminous mixtures of asphaltic pavement material. Their research focused on effect of a cyclic water vapor to asphalt concrete mixtures. In further, Ramli *et al*. (2001) researched the phenomenon by using the cyclic vapor test to asphalt mixture that focused on *Butonic* Mastic Asphalt (BMA) mixture. These researches have been focused only for effect of a cyclic water vapor, a condensation process, i.e. a process of evaporation of water from the sub-grade up to the sub-base and base layers during the day followed by condensation when the temperature decreases in the night. Normally, the process occurred in the area of high ground water level and bad sub-base and base layers that contain much fine grained materials, and happened cyclically for a long time and may damage the pavement material from the bottom of its layer (Siswosoebrotho *et al.*, 2003). Unfortunately, these researches do not describe the effect of water infiltration to asphalt pavement actually, moreover to represent the impact of flood puddle phenomenon to asphalt pavement durability in the real world.

In order to overcome the above restriction, one of main purposes of the present research is to develop a *Modified Immersion* test in order to grasp the effect of water infiltration on flood puddle that have been occurring in tropical condition to road pavement durability, in particular to surface layer of the pavement that constructed from asphaltic mixture.

In other issue, supplied limitation of petroleum asphalt in recently years for bitumen material of asphaltic mixture in some countries in Asian developing countries, including Indonesia, lead to attempts to utilize another bitumen source such as rock asphalt deposit. In particular in Indonesia case, Indonesia government attempts to exploit the rock asphalt deposit that existed in large quantities in *Buton* Island, South-East Sulawesi, Indonesia, named locally as *Butonic* Asphalt or *Asbuton*. Unfortunately, the utilizations of the *Asbuton* as instead of petroleum asphalt as binder material in an asphaltic mixture have given restriction on the mixture performance. An effort to combine the *Asbuton* into petroleum asphalt was one of solution in order to increase the performance and still utilize the *Asbuton* in the large portions. In this regard, some scholars have been researched performance of asphaltic mixture when its binder material is combination between petroleum asphalt and the *Asbuton*. Ramli *et al.* (2001a) researched the characteristics of an asphaltic mixture when petroleum asphalt was combined with Asbuton in the large portion, namely the *Butonic Mastic* Asphalt (BMA) mixture. They extended to research durability performance of the BMA mixture in order to describe effect of water vapor cyclic phenomenon (Ramli *et al.* 2001b). In further, laboratory performance of *Asbuton* utilization in Hot Rolled Asphalt and *Superpave* mixes was conducted (Subagio *et al.*, 2003; 2005; 2007). Subagio *et al.*, (2009) also researched utilizing of *Refined Butonic* Asphalt (*Retona*) blend on asphaltic concrete wearing course (AC-WC) mixture. These researches focused on fatigue, plastic deformation, and stiffness modulus of the asphaltic mixtures. The top author of the present paper in the last previous research also concerned to utilizing *of* liquid *Asbuton* as partial replacement of petroleum asphalt bitumen on a Porous Asphalt mixture (Ali *et al.*, 2010).

In regarding to contribute and to extend on the both above issues, the present research aims to develop an experimental study in order to grasp effect of flood puddle to durability of road pavement in particular asphalt concrete mixture containing *Retona* additive. The experiment carries out *Modified Immersion* test to represent the phenomenon and *Marshall Immersion* test as reference. The research adopts three types parameters of durability indexes to describe the asphalt mixture durability, i.e. the retaining strength index (RSI), the first durability index (FDI), and the second durability index (SDI).

The remainder of this paper is composed as follows. The next chapter presents the methodology of the experimental study. Then, Chapter 3 demonstrates the results of the experimental activities. The final chapter provides discussion related to the results and summarizes important findings.

2. METHODOLOGY OF THE LABORATORY EXPERIMENT

2.1. Immersion test to represent flood puddle phenomenon on road pavement

This research carries out two types of immersion tests in order to represent treatment of the flood puddle phenomenon on asphalt pavement in the real world. The both tests are *Marshall Immersion* test and *Modified Immersion* test. The procedures of the tests are explained as below.

The *Marshall Immersion* test is started from the preparation of test specimen of an asphaltic mixture. Standard size of the specimen is 7.5 cm in high and 10 cm in diameter. The immersion process is conducted at 60^{o}C during 24 hours (one day). After finished the immersion period, the surface of specimen is visually tested for remarkable of stripping and an estimated until nearest 5% of the residual coated area. Resistance of the asphalt mixture to water damage is carried out by measurement on changing in stability values of the specimens. In this regard, the *Marshall* stability test is conducted to the specimens that divided into 2 (two) groups specimens sampling, i.e. a group of specimen that treated immersion in water at 60^{o}C during 30 minutes, and a group for immersion during 24 hours at the same water temperature.

Furthermore, in order to indicate effect of the flood puddle to durability of the asphalt mixture after immersion period over 24 hours, a modified immersion test is developed. Modification of immersion duration test more than one day is conducted, where three periods of immersion periods, i.e. 3, 5, and 7 days is used. Three specimens for each immersion period are prepared, and then the specimens are immersed in water at 60^{o}C according to their immersion duration. After the immersion, the *Marshall* stability of the specimens is measured in following *Marshall Immersion* test procedure.

2.2. Durability index of asphalt concrete mixture

In this research, some types of durability index are used in order to represent retaining strength of asphalt mixture after is treated by *Marshall Immersion* and *Modified Immersion* tests. The indexes are explained in the following paragraphs.

2.2.1 Retaining strength index (RSI) of *Marshall Immersion* test

The value of the retaining strength index (RSI) of a *Marshall Immersion* test is determined by using the below formula:

$$RSI = \frac{S_2}{S_1} x 100\% \qquad (1)$$

Where S_1 and S_2 are values of *Marshall* stability test (in unit kg) after immersion during T_1 and T_2 minutes respectively. The minimum value of the RSI that showed an asphalt mixture still enough stable is 75%. In other words, the limit value of the RSI indicates that bituminous mixture is assumed to be strong enough to hold on damage caused by influence of water when the IRS value is equals or more than the limit value.

2.2.2 Durability index of *Modified Immersion* test

In order to represent durability of asphalt mixture after treated by immersion as represent of flood phenomenon, this research adopt two types of durability index, i.e. the first durability index (FDI) and the second durability index (SDI). Derivation of calculation of the both indexes represents the stability curve as shown by Figure 1. The both indexes are explained as below.

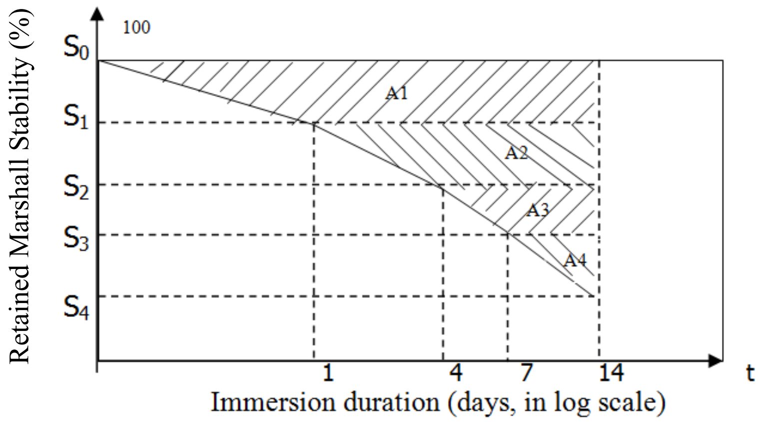

Figure 1 Basic concept of the first and the second durability index

The first durability index (*FDI*) is formulated as follows (Ramli *et al.*, 2001, and Siswosoebrotho *et al.*, 2003):

$$FDI = \sum_{t=0}^{n-1} \frac{S_i - S_{i+1}}{t_{i+1} - t_i} \tag{2}$$

Where S_i, and S_{i+1} are percentage of retaining strength after immersion during t_i and t_{i+1} days respectively.

Positives values of the *FDI* indicate stability lost, while the negatives values indicate stability obtained. In application, usually the *FDI* represents percentage of stability lost for one day of test (Ramli *et al.*, 2001, and Siswosoebrotho *et al.*, 2003).

The second durability index (*SDI*) is formulated as follows (Ramli *et al.*, 2001, and Siswosoebrotho *et al.*, 2003):

$$SDI = \frac{1}{t_n} \sum_{i=1}^{n} A_i = \frac{1}{2t_n} \sum_{i=0}^{n-1} \left(S_i - S_{i+1}\right)\left[2t_n - \left(t_i + t_{i+1}\right)\right] \tag{3}$$

Where t_n is total duration of immersion that considered, while A_i represents the square of lost strength for *i* immersion period.

According to the Equation (3), the *SDI* is meant as wide area of stability lost that located between durability curve and S_o (Ramli *et al.*, 2001, and Siswosoebrotho *et al.*, 2003). This index also represents stability lost in a day when its value is positive. In contrary, the negative value indicates stability gained as the former index, the FDI.

The three durability indexes can be utilized to represent the lost stability or strength of an asphalt mixture appropriately. When we interest to the lost stability in term of ratio between two stability values directly, the RSI is appropriate. In further, the FDI is more appropriate when the interest is to capture directly the strength difference between two stability testing results on two time periods serially. Slightly similar to the FDI, the SDI interests also to capture the lost strength when the stability lost is represented by wide area.

2.3. Steps of experimental activities and specimen need

The experimental activities in laboratory that carried out in this research consists of four steps activities. The first step is preliminary laboratory tests in order to know aggregate and asphalt materials properties as constitute of asphalt concrete mixture. The second step is activities to determine optimum asphalt content (OAC) and optimum *Retona* content (ORC) of asphaltic concrete mixtures containing and un-containing *Retona* additive respectively. The third step is testing of *Marshall Immersion* in order to provide retaining strength index of asphalt mixture durability. The last is testing of *Modified Immersion* in order to provide the both durability index, the FDI and the SDI, of the mixtures.

Estimation of specimen need that produced in the three last of the above experimental activities is showed by Table 1. The Table shows that the experiment needs 84 specimens to conduct the three steps of experimental activities, i.e. step to determine optimum asphalt content (OAC) and optimum *Retona* content (ORC) of the mixtures, step to treat *Marshall Immersion* test, and step to treat *Modified Immersion* test. Those steps need 30, 36, and 18 specimens respectively.

Table 1 Estimation of specimen need

1. Determination of OAC & ORC			
Asphalt content (%)	Retona content (%)	No. specimens to obtained OAC & ORC	Total of specimens
4.5	0	3 + 3	6
5.0	5	3 + 3	6
5.5	10	3 + 3	6
6.0	15	3 + 3	6
6.5	20	3 + 3	6
2. *Marshall Immersion* test (60°C)			
Asphalt content (%)	Immersion duration (hours)	No. specimens of AC & ARC	Total of specimens
-0.5 OAC	0.5	3 + 3	6
OAC	0.5	3 + 3	6
+0.5 OAC	0.5	3 + 3	6
-0.5 OAC	24	3 + 3	6
OAC	24	3 + 3	6
+0.5 OAC	24	3 + 3	6
3. *Modified Immersion* test			
Asphalt content (%)	Immersion duration (days)	No. specimens of AC & ARC	Total of specimens
OAC	3	3 + 3	6
OAC	5	3 + 3	6
OAC	7	3 + 3	6
Total number of specimen			84

3. RESULTS OF THE LABORATORY EXPERIMENT

The result of experimental activities in laboratory that included preliminary test of mixture materials, *Marshall* testing, immersion test, and calculation of durability index values, are explained as below.

3.1 Preliminary laboratory test

Results of the preliminary laboratory test include aggregate properties, asphalt and *Retona* properties, and design mix of asphaltic concrete. The standard methods that are used in these tests consist of the *Indonesian Specification* for Asphalt Concrete Mixture un-containing and containing *Asbuton* (SNI, 1999; Dept. PU, 2007), *British Standard*, and *AASHTO*. The results are provided as below.

3.1.1 Aggregate properties

This research used coarse and fine aggregates from crushed rock and sand respectively, while fillers of asphalt concrete mixture are "stone-dust" and *Retona* for the mixture un-containing and containing the *butonic* additive respectively. The laboratory tests to evaluate the properties of coarse aggregates included specific gravity, LA abrasion, water absorption, and flakiness index. The tests for fine aggregates included specific gravity, water absorption, and sand equivalent, while for filler were only specific gravity and water absorption. The results of these tests and the adopted specifications are showed in Table 2. The Table shows that the aggregate properties fulfill the specification. Then, the aggregate could be used to produce specimen of asphalt concrete mixture.

Table 2 Tests results of aggregates properties

Characteristics	Testing methods	Unit	Result	Specification
1. Coarse aggregate				
Bulk specific gravity	AASHTO T85-1996	-	2.620	≥2.5
SSD specific gravity	AASHTO T85-1996	-	2.670	-
Apparent specific gravity	AASHTO T85-1996	-	2.77	-
Water absorption	AASHTO T85 – 1996	%	1.880	≤ 3
LA Abrasion	AASHTO T96 – 1994	%	26.737	≤ 40
Flakiness index	BSI 812 – 1975	%	15.50	≤ 25
2. Fine aggregate (Sand)				
Bulk specific gravity	AASHTO T84 – 1995	-	2.60	≥ 2.5
SSD specific gravity	AASHTO T84 – 1995	-	2.66	-
Apparent specific gravity	AASHTO T84 – 1995	-	2.78	-
Water absorption	AASHTO T84 – 1995	%	2.60	≤ 3
Sand equivalent	AASHTO T176	%	76.439	≥ 50
3. *Filler*				
Bulk specific gravity	AASHTO T84 – 1995	-	2.630	≥ 2,5
SSD specific gravity	AASHTO T84 – 1995	-	2.690	-
Apparent specific gravity	AASHTO T84 – 1995	-	2.830	-
Water absorption	AASHTO T84 – 1995	%	2.648	≤ 3

3.1.2 Bitumen properties

The type of bitumen which used in this research is petroleum asphalt (Pen 60/70) from asphalt storage of Indonesia Civil Work Department branch South Sulawesi Province in Makassar, Indonesia. The laboratory tests that were conducted in order to evaluate the bitumen properties included penetration, ductility, softening point, flash point, burning point, specific gravity, loss of weight, and solubility. The results of these tests and the adopted specifications are provided in Table 3. The Table shows that the aggregate properties fulfill the specification. Then, the bitumen could be used to produce specimen of asphalt concrete mixture.

Table 3 Tests results of bitumen property

Characteristics	Testing methods	Unit	Result	Specification
Penetration (25˚C,5 sec., 100gr)	AASHTO T49 – 1997	0.1 mm	65	60 - 79
Ductility (25˚C,5 cm/minute)	AASHTO T51 – 1994	Cm	>100	≥ 100
Softening point (Ring & Ball)	AASHTO T53 – 1996	˚C	48.5	48 - 58
Flash point (Clev. Open Cup)	AASHTO T48 - 1996	˚C	315	≥ 200
Burning point (Clev. Open Cup)	AASHTO T48 – 1996	˚C	335	-
Specific gravity (25˚C)	AASHTO T228 – 1990	-	1.029	≥ 1
Loss of weight (163˚C,5 hours)	AASHTO T47 – 1998	% weight	0.321	≤ 0.8
Penetration after loss of weight	AASHTO T49 – 1997	%	58	≤ 54
Ductility after loss of weight	AASHTO T51 – 1994	Cm	>100	≥ 50

3.1.3 *Refined Butonic Asphalt* (*Retona*) properties

The type of *Retona* that used in this research is *Retona P6014* from storage of *PT. Olahan Bumi Mandiri* (OBM), Jakarta, Indonesia. The *Retona* is extracted from *Asbuton* asphalt, rock asphalt from *Lawele*, *Buton* Island, Indonesia, where the properties of the *Retona* is showed by Table 4. It shows that the bitumen content of *Retona* additive was high sufficient (55% – 60%), and its bitumen properties was very soft (0 – 10 dmm).

Table 4 Characteristics of *Retona P6014* material

Characteristics	Unit	Values
Shape	-	*Powder*
Density	kg/lt.	1.45
Size	inch	20 *mesh*
Bitumen content	%	55-60
Mineral content,	%	40-45
Mineral pass sieve #200 mesh	%wt	93
Penetration	dm m	0-10
Softening Point R&B,	˚C	130 min

3.1.4 Design mix of asphaltic concrete mixture

This research prepared two types of asphalt mixtures, namely asphaltic concrete (AC) mix with Asphalt Pen 60/70, and asphaltic concrete containing Asphalt Pen 60/70 and *Retona P6014* additive (ACR). Aggregate composition of the mixtures based on the aggregate type IV of *Indonesia National Standard* (SNI 1998). In order to determine optimum asphalt content (OAC) of AC mix by using *Marshall* testing, the bitumen content of the mixture was varied from 4.5% to 6.5%, at 0.5% increment. As well as determination of optimum *Retona* content (ORC) of the ACR mixture through variation of the additive from 5% to 20% at 5% increment. In further, specimens under optimum condition of the both mixtures were prepared to *Marshall Immersion* test and *Modified Immersion* test. Sensitive analysis under ±0.5% from optimum asphalt content of the mixtures also was carried out on the *Marshall Immersion* test.

3.2 Bitumen content and *Marshall*'s properties of the optimum mixtures

The *Marshall* test according to AASHTO or ASTM method was conducted in order to determine OAC and ORC of the AC and ACR mixture respectively. There are 6 (six) parameters to be considered, namely *Marshall* Stability, *Marshall* Flow, *Marshall* Quotient (MQ), VIM, VIM, VMA, and VFWA. Optimization the six parameters to specification values of SNI 1998 in relation with the in-service behavior during pavement life resulted OAC about 6.14% and ORC about 14%. The performance of the six parameters under optimum condition of the two mixtures is presented in Table 5. It shows that almost parameters values fulfill specification of the both mixtures.

Table 5 *Marshall*'s properties of asphalt mixture on optimum condition

Types of asphalt mixture	*Average value of Marshall* properties					
	Stability (kg)	*Flow* (mm)	MQ (kg/mm)	VIM (%)	VMA (%)	VFWA (%)
AC	1,170.65	3.11	380.07	5.94	17.27	65.62
ACR	1,368.20	2.41	531.50	5.89	17.22	65.82
Specification AC	> 750	2 – 4	> 200	3 – 5	> 15	> 65
Specification ACR	> 800	> 3	> 250	3.5 – 5.5	> 15	> 65

3.3 Durability index of AC and ACR mixtures

According to the stabilities values of the specimens after treated by immersion test, the durability indexes values (RSI, FDI, and SDI) of the mixtures are calculated. The RSI values of AC and ACR mixtures after one-day (24 hours) immersion under condition optimum asphalt content (OAC), 0.5% increment of OAC, and 0.5% decrement of OAC are presented in Figure 2. Figure 3, Figure 4, and Figure 5 show the RSI values, the FDI values, and the SDI values of the both types of the mixtures respectively after treated by immersion during one, three, five, and seven days.

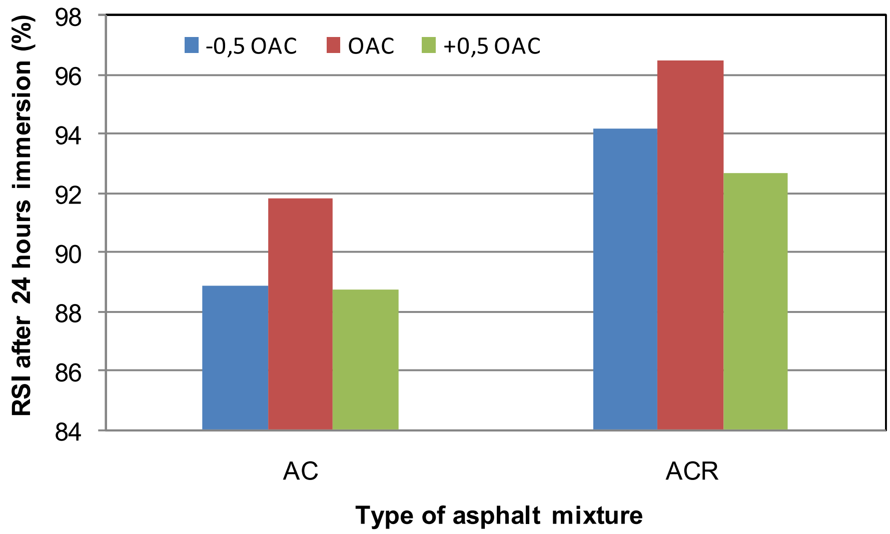

Figure 2 Retained strength index (RSI) of AC and ACR mixtures

Figure 2 shows that RSI values under optimum condition of the both mixtures are still better than the mixtures under condition 0.5% increment and 0.5% decrement of theirs optimum conditions. In comparing between the AC and the ACR mixtures, the Figure shows that RSI values of ACR mix are better than RSI of AC mix. Even though, the RSI values of the two mixtures are still more than 75%, a minimal value of RSI to obtain that an asphaltic mixture has still good strength.

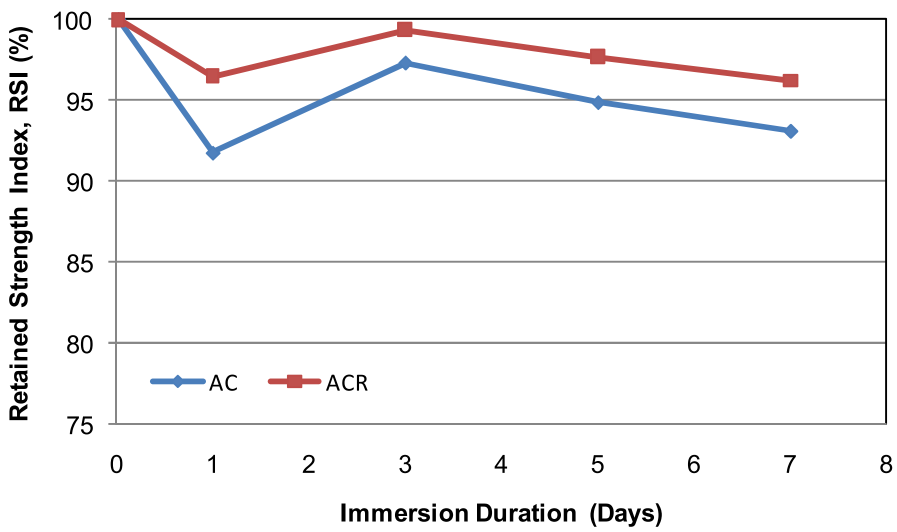

Figure 3 RSI values of AC and ACR mixtures after treated by *Modified Immersion* test

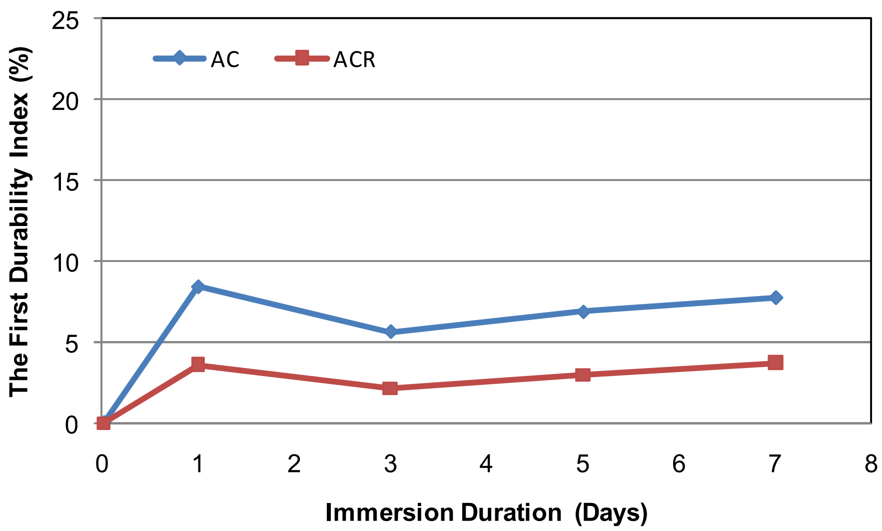

Figure 4 FDI values of AC and ACR mixtures after treated by *Modified Immersion* test

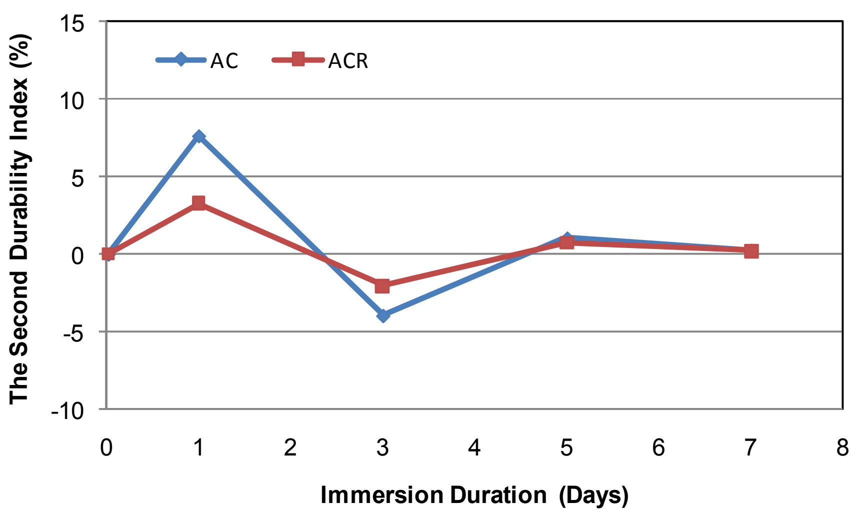

Figure 5 SDI values of AC and ACR mixtures after treated by *Modified Immersion* test

Figure 3 shows that the RSI values of the two mixtures during the inclining of immersion duration decrease to follow the increasing of the immersion duration. However, the RSI values are slightly increasing when the immersion duration achieve until 3 (three) days. Generally, the RSI values of the both mixtures during the immersion through 7 (seven) days are upper than 90%, where the IRS values of ACR mix are higher than the values of AC mix.

Figure 4 shows that the FDI values of the AC and ACR mixtures increase generally to follow the immersion duration, where the values of the two mixtures are slightly decreasing until the 3 days of the immersion duration. In further, contrary to RSI values, the FDI values of ARC mixture are lower than AC mixture.

Figure 5 shows that the SDI values of the both types of the mixtures are contrary to FDI values. The SDI values decrease generally in following the increasing of immersion duration, where the values at three days of the immersion duration are lower than zero. In comparing the SDI values between the both mixtures, the Figure shows slightly different only for one and three days of the immersion duration.

4. DISCUSSIONS AND CONCLUSIONS

4.1 Discussion

According to the results of the laboratory experiments that presented in Chapter 3, this section will discuss some important findings as below.

The both mixtures, AC and ARC mixes, have good sensitivity related to retained strength of the mixtures when their bitumen content occur 0.5% increment and or 0.5% decrement from theirs optimum condition. They are indicated by the RSI values of the both types of the mixtures which are still upper than 75% after they were treated immersion during 24 hours.

In further, increment of immersion duration from 1 (one) day through 3 (three) days produced increasing of the mixtures strength as shown in Figure 3. In other word, the increment of duration resulted decreasing of deterioration level of the mixtures durability, as indicated by declined of their FDI and SDI values that are presented in Figure 4 and Figure 5 respectively. Even though, increment more of the immersion duration declined of the mixtures strength as well as increasing deterioration level of their durability. These phenomena could be explained by reason that occurred symptom of water infiltration into the mixtures to fill void in the mixes. Regarding to 1 until 3 days of immersion, the mixtures strength increased due to the water infiltrate the void through the maximum void of the mixture is fulfilled. Then, after the immersion is more increase, the maximum void is exceeded, so that the strength starts to decrease again.

Furthermore, comparing of durability deterioration between the both mixtures shows that the ARC mixture is more durable than the AC mixture. On the other word, addition of *Retona* additive into asphalt concrete mixture caused the mixture more strength against deterioration of water infiltration. These phenomena could be explained by reason that nature asphalt on the *Retona* consist of *resin poly-aromatic* compound. The compound could raise stability effect of asphalt binder in asphaltic concrete mixture.

Finally, adapted *Marshall Immersion* test through *Modified Immersion* test in order to represents the effect of the flood puddle to durability asphaltic concrete mixture in the real world showed good performance by the adopted three types of durability indexes, i.e. RSI, FDI, and SDI.

4.2 Conclusions

In this paper, the authors have attempted to describe effect of flood puddle to durability of road pavement, in particular surface layer or asphalt concrete mixture containing *Refined Butonic Asphalt* (*Retona*). The phenomenon of the flood puddle that occur when rain season in tropical countries, usually causes the road pavement under water or awash. In this regard, an experimental study in laboratory was conducted, where flood puddle phenomena in the real world was represented by *Modified Immersion* test. The experimental treated immersion test during 1, 3, 5, and 7 days to the two types of asphalt mixture, i.e. asphalt concrete mixture containing *Retona* additive, and the mixture un-containing *Retona* as reference. In further, the research adopted durability index concept in order to grasp effect of the flood puddle to durability of asphalt mixture. There are three types of durability index that introduced in this research, i.e. retaining strength index (RSI), the first durability index (FDI), and the second durability index (SDI). The first of the three represent durability of the mixtures after is treated by *Marshall Immersion* test. The two last represent durability results of the mixture after are treated by *Modified Immersion* test.

Experimental results show that the both types of the mixtures have still RSI values more than 75% after are treated by *Marshall Immersion* and *Modified Immersion* tests. This means that the asphalt mixtures are still enough durable to retain the flood puddle until seven days. However, the asphalt mixture un-containing *Retona* experienced drastically decreasing of RSI value to follow increasing of the immersion duration, in comparing the mixture containing *Retona*. In further, FDI and SDI values of the mixtures also indicated that deterioration of durability of the asphalt mixture containing Retona was smaller than the mixture un-containing *Retona*. Overall, the laboratory experiments showed that the asphalt concrete mixtures still retained until seven days immersion, where the mixture containing *Retona* was more durable than the other mixture.

In brief, the *Modified Immersion* test showed good appearance in order to grasp the deterioration of asphalt mixtures durability due to the flood puddle during some days. The authors expect that the proposed method could be applied for another type of asphalt mixture like asphalt porous, and also to see the effects of the treatment to others performances of the asphaltic mixtures such as fatigue, plastic deformation, and stiffness modulus, in further studies.

ACKNOWLEDGMENTS

We would like to express our thanks and appreciation to Mr. Kasim Pateha (In memorian), Mr. Amiruddin Basir, Mrs. Dewi Rosaria Amin, Mr. Najamuddin, and Civil Engineering Department of Hasanuddin University which allow us to access and utilized their data for the purpose of this paper. Without their cooperation, this paper would not be possible to be arranged.

REFERENCES

Ali, N., Tjaronge, M.W., Samang, L., Djamaluddin, R., (2010), Mechanical Properties of Porous Asphalt Containing Liquid Asbuton as Partial Replacement for Petroleum Asphalt Bitumen, **Proceeding of 7th International Symposium on Lowland Technology**.

American Association of State Highway and Transportation Officials (AASHTO), (1998), **Standard specification for transportation materials and methods of sampling and testing**.

Civil Work Department of Republic Indonesia (Dept. PU), (2007), Hot Mix Asphalt Mixture, **Volume 5: Specification** (In Indonesian Language).

Indonesia National Standard (SNI), (1999), Guidance of Hot Mix Asphalt Mixture Design**, Engineering Guidance No. 025T/BM/1999**, (In Indonesian Language).

Ramli, M.I, Hustim, M., Siswosoebrotho, B.I., Hendarto, S., (2001a), The Characteristics of Butonic Mastic Asphalt (BMA) Mixture, **Proceeding of the 4th Symposium of Indonesia Inter-University Forum for Transportation Studies** (In Indonesian Language).

Ramli, M.I, Siswosoebrotho, B.I., Hendarto, S., (2001b), Influence of a cyclic water vapor on Durability of Butonic Mastic Asphalt (BMA) Mixture, **Journal of Indonesia Inter-University Forum for Transportation Studies, Vol. 4**, No. 2, pp. 20-30 (In Indonesian Language).

Siswosoebrotho, B.I., Karsaman, R.H, Setiadji, B.H., (2003), Development of a cyclic water vapour test for durability assessment of bituminous mixtures for pavement material, **Journal of the Eastern Asia Society for Transportation Studies, Vol. 5**, No. 6, pp. 940-950.

Subagio, B.S., Karsaman, R.H., Adwang, J., Fahmi, I., (2005), Fatigue Performance of Hot Rolled Asphalt and Superpave mixes using Asbuton as fine aggregates and filler, **Journal of the Eastern Asia Society for Transportation Studies, Vol. 6**, No. 5, pp. 1207-1216.

Subagio, B.S., Rahman, H., Hendarto, S., Philips, S.J., (2009), Stiffness Modulus of Asphaltic Concrete Wearing Course (AC-WC) Mix Containing RETONA BLEND 55® : Theoretical and Experimental Analysis, **Proceeding of the Eastern Asia Society for Transportation Studies, Vol. 7**.

Subagio, B.S., Rahman, H., Fitriadi, H., Lusyana, (2007), Plastic Deformation characteristics and Stiffness Modulus characteristics of Hot-Rolled Sheet (HRS) containing Buton Asphalt, **Proceeding of the Eastern Asia Society for Transportation Studies, Vol. 6**.

Subagio, B.S., al. (2003), Development of Laboratory Performance of Indonesian Rock Asphalt (Asbuton) in Hot Rolled asphalt Mix, **Journal of the Eastern Asia Society for Transportation Studies, Vol. 5**.