International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

September 2022 | Issue 52 | Volume 14 | Number 3 | Pages 168-174

EFFECTS OF RICE HUSK ASH AND HYACINTH PLANT ON PAVEMENT AC-WC

N. Widyaningsih [1] W.H.M.W. Mohtar [2] N.I.M. Yusoff [1] R.K. Kinasih [1]

1. Department of Civil Engineering, Faculty of Engineering, Universitas of Mercu Buana, Jakarta, Indonesia
nunung_widyaningsih@mercubuana.ac.id, nabila@mercubuana.ac.id, re.kinasih@mercubuana.ac.id
2. Department of Civil Engineering, Faculty of Engineering and Built Environment, University of Kebangsaan Malaysia, Bangi, Selangor Darul Ihsan, Malaysia, hanna@ukm.edu.my

Abstract- This research is to find an alternative option to replace Portland cement filler by combining of the waste of rice husk ash and water hyacinth ash. Using a Marshall Test and Wheel Tracking Test, with a composition of 60% rice husk ash and 40% water hyacinth ash. Percentage taken from this research is 100: 0, 50:50, 0: 100. From the results of research conducted on the AC-WC mixture obtained CAO of 6.2%. In 7% cement filler, the stability was 2357.7 kg from the average yield of 5%, 6% and 6.5%. From the Residual Strength Index (RSI) all specimen is below requirement. Whereas in the composition of the 50:50 filler (cement filler compared to 60% ash of rice husk ash and 40% of hyacinth ash) obtained stability of 2424.78 kg with each soaking for 30 minutes at a temperature of 60 °C. in the marinade for 24 hours using a 50:50 filler composition with a temperature of 60 °C obtained stability of 2290.73 kg. The Wheel Tracking test a dynamic stability value of 257.1 track / mm, while for the composition of filler 50:50 a value of 218.1 track / mm [20].

Keywords: Filler, Portland Cement, Rice Husk Ash, Hyacinth Ash, Marshall Test and Wheel Tracking Test.

1. INTRODUCTION

According to the Central Statistics Agency (2018), the area of rice harvest in Indonesia in 2018 was 10.9 million hectares, so it is estimated that the total rice production in 2018 is 56.54 million tons of milled dry grain, and rice production will total 32.42 million tons. So, the amount of rice husk in 2018 is 24.12 million tons. According to [12], water hyacinth ash is an aquatic plant that is dried and then burned to ash. Water hyacinth can multiply rapidly (3% per day). Here, rice husk ash is an agriculture product from rice mills in Banten, Sentul Kragilan Serang, while the water hyacinth raw material was from Banten, Situ Belungun Sentul Kragilan Serang.

Rice husk ash and water hyacinth can be used as a substitute for cement [2]. In addition, obtaining rice husk ash and water hyacinth is quite easy. Rice husk ash and water hyacinth have a silica content that is expected to improve the quality of AC.

Research testing was carried out at the DKI Jakarta Provincial Highways Department Laboratory, DI. Panjaitan Kav., East Jakarta, Indonesia. This research is level 3 (basic) that the Level of Technological Capability. This research is expected to get experience in research with partners and hopefully we can take experience and review laboratories at University of Kebangsaan Malaysia. The partners, W. Hanna and N.I. Yusoff are experts in Transportation field, focusing in pavement materials development and new material discovering. Besides, University of Kebangsaan Malaysia have a complete and proper material laboratory which can give a big help for perfection result of this proposed research.

In addition to getting rice husk ash and hyacinth is quite easy. Rice husk ash and hyacinth have silica content and are expected to improve the quality of the asphalt concrete mixture. According to N. Widyaningsih and B. Sutanto (2018) utilization of hyacinth for this plant is still very rare because the majority of people know that the use of hyacinth is only for making crafts, this plant can grow up to 1.9% per day. Although the hyacinth plant has a high fiber content (20% fiber) so we try to mix it as a filler.

2. METHODS

Research on the mixture of asphalt and rice husk ash and water hyacinth requires several tests, including testing for aggregates (fine, coarse, and filler) including specific gravity, flake index and Los Angeles. Asphalt testing includes penetration testing, softening point, ductility, flash point, specific gravity, penetration after thin film over test (TFOT), and softening point after TFOT. This research was conducted at the Laboratory of Bina Marga Department of DKI Jakarta Province using the Marshall test method and Wheel Tracking which is the basis of this test to obtain a conclusion that has been analyzed.

2.1. Asphalt

According to S. Sukirman (2003), asphalt is defined as an adhesive material (Cementitious), black or dark brown, with the main element of bitumen. Asphalt can be obtained in nature or residue from petroleum refineries. Asphalt is a material at room temperature in the form of solid to

slightly dense and is thermoplastic. So, asphalt will melt if heated to a certain temperature, and freeze again if the temperature drops. Together with the aggregate, asphalt is a material that forms a mixture of road pavement [6]. The amount of asphalt in the pavement mixture ranges from 4-10% based on the weight of the mixture, or 10-15% based on the volume of the mixture [19].

2.2. Aggregate

Aggregate is generally defined as a hard and solid earth crust formation. ASTM defines aggregate as a material consisting of solid minerals, in the form of a large mass or in the form of fragments.

2.3. Portland Cement

According to Fadhilah, et al. (2020), Portland Cement is an industrial product that uses the main raw material of limestone or limestone. This limestone is mixed with clay or other substitute material, which then will produce a solid product in the form of powder. Limestone or limestone is a natural material containing Calcium Oxide (CaO) compound, whereas clay is a natural material containing Silica Oxide (SiO_2) compound, Aluminum Oxide (Al_2O_3), Iron Oxide (Fe_2O_3), and Magnesium Oxide (MgO). To produce cement, the raw material is burned until it is melted and added to a certain amount of gypsum [8].

2.4. Rice Husk

Ash from rice husk burning, which is essentially just waste, has turned out to be a fairly high source of silica/carbon. The results of further pyrolysis of rice husk combustion indicate that the SiO_2 content reaches 80-90%. One of the most attempted attempts to utilize rice husk ash is to react with NaOH solution to produce broad industrial use of sodium silicate, such as a filler in soap and detergent, adhesive, and silica gel. Rice husk or rice husk is waste from the rice mill where rice husk is the second largest part after rice [2]. From the grain milling process, 16.3%-28% husks will be produced. Rice husk ash is a waste from burning rice husk. The use of rice husk ash is intended as an alternative material to replace the stone ash (filler) in the asphalt mixture. This is because rice husk ash also has several chemical elements contained by rock ash.

2.5. Water Hyacinth

Water hyacinth has been widely used for materials woven home furniture (tables, chairs), bags, sandals and so forth (3). Water hyacinth body between 40-80 cm, this plant is rich in Alcan nutrient has a long stem but with short roots. Water hyacinth contains Calcium (Ca), Sodium (Na), Magnesium (Mg), Ferum (Fe), Cupper (Cu), Potassium (K), Manganese (Mn). Water hyacinth contains about 90% water content by reducing the weight from 10 kg wet to 1 kg dry [15]. In a dry state of water hyacinth. According to Widyaningsih and Sutanto (2018), utilization of water hyacinth is still very rare, as most people know of its use only for making handicrafts; the plant can grow up to 1.9% per day. The water hyacinth plant has a high fibre content (20% fibre), so we attempted to mix it as a filler.

Water hyacinth is an aquatic plant that has advantages in photosynthesis, oxygen supply and absorption of sunlight. Another advantage of water hyacinth is that it can absorb nitrogen and phosphorus compounds from polluted water, potentially for use as a major component of wastewater cleaners from various industries and households. According to R. Makofane (2018) expresses the content of the dried water hyacinth stalk as water hyacinth has a cellulose content of 59.14% and lignin of 7.69%. Water hyacinth has a special character that is high levels of cellulose and organic matter. From these data, water hyacinth is a potential organic material to be developed, among others, for organic fertilizer and growing media [17].

2.6. Marshall Test

According to S. Sukirman (2003), the Marshall device is a press device equipped with a proving ring with a capacity of 2500 kg, or 5000 pounds. The proving ring is equipped with a watch useful for measuring the stability of the mixture. In addition, there is a wristwatch flow (flow meter) to measure the plastic discharge (flow). Marshall tests are usually equipped with other parameters, such as VIM (void in mix, or often abbreviated as 'voids') and VMA (void in mineral aggregate), in addition to a graph of asphalt content vs. compressive strength, which shows the optimum number for certain asphalt levels (usually around 5-5.8% for surface AC) relating to the highest achievable compressive strength [10].

2.7. Calculation of Residual Strength Index (RSI) [5]

The function of this test is to determine the durability of the pavement due to the influence of weather and water:

$$RSI = 1 - \left(\frac{S_1 - S_2}{S_1} \right) \times 100\% \quad (1)$$

where, *RSI* is Residual Strength Index (%), must be greater than 75%, S_1 is Average Marshall stability after soaking for 30 minutes (kg) and S_2 is Average Marshall stability after soaking for 24 hours (kg).

2.8. Wheel Tracking

This test aims to test the deformation resistance that occurs due to the wheels moving on the surface of the wheels. The tools used are Wheel Tracking by 30×30×5 cm mold [19].

3. RESULTS AND DISCUSSIONS

3.1. Marshall Test Result [20]

Marshall Test Results to get Optimum Asphalt Leves as Figure 1 is:

a) VMA testing with 5% content, it is found 13.773% so that the tested object does not meet the SNI with a minimum of 15%.

b) VMA testing with levels of 6% obtained 15.213% so that the tested object meets the requirements of SNI with a minimum of 15%.

c) VMA testing with a level of 6.5% obtained 17.988% so that the object being tested meets the SNI with a minimum of 15%.

d) VFA testing with 5% levels obtained 73.473% so that the tested object meets the SNI requirements.
e) VFA testing with 6% levels obtained 78.808% so that the tested material meets the SNI requirements with a minimum of 65%.
f) VFA testing with a level of 6.5%, it is found 71.233% so that the object being tested meets the SNI requirements with a minimum of 65%.
g) VIM testing with a level of 5%, 3.721% is obtained so that the object being tested meets the SNI requirements with a minimum of 3% and a maximum of 5%.
h) VIM test results with 6% levels obtained 3.226% so that the tested object meets the SNI requirements with a minimum of 3% and a maximum of 5%.
i) VIM testing with a level of 6.5%, it is obtained 5.360% so that the tested object does not meet the SNI requirements with a minimum of 3% and a maximum of 5%.
j) the Stability test with a level of 5% obtained 1918.2 kg so that the object tested meets the SNI requirements with a minimum of 800 kg.
k) the Stability test with a level of 6% obtained 2357.7 kg so that the object being tested meets the SNI requirements with a minimum of 800 kg.
l) the Stability test with a level of 6.5%, it is obtained 2146.7 kg so that the object being tested meets the SNI requirements with a minimum of 800 kg. From the results of testing with a level of 5% obtained 2.84 mm so that the object tested meets the SNI requirements with a minimum of 2 mm and a maximum of 4 mm.
n) From the test results with a level of 6% yield obtained 2.43 mm so that the object tested meets the SNI with a minimum of 2 mm and a maximum of 4 mm.
o) From the results of testing with a level of 6.5% obtained 2 mm so that the tested object meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
p) From the Marshall test results obtained Optimum Asphalt Levels (CAO) with cement filler and immersion for 30 minutes by 6.2%.

3.1.1. Result from Optimum Asphalt Level 6.2% with Composition of Cement Filler at 30 Minute Residual Strength Index (RSI) [20]

From Figure 1, it can be seen that the VMA, VFA and Flow by IKS yield of 30 minutes meet the minimum requirements but the stability and VIM are only partially between 100:0, 50:50 and 0:100. So that a line that meets all these criteria is drawn, the optimum filler composition ratio of cement against 60% husk ash +40% water hyacinth ash is 50:50.

3.1.2. Result from Optimum Asphalt Level 6.2% with Composition of Cement Filler at 24 Hours Residual Strength Index (RSI) [20]

From Figure 2, it can be seen that the Stability and Flow by IKS yield of 30 minutes meet the minimum requirements of the requirements, but the VMA, VFA and VIM are only partially between 100:0, 50:50 and 0:100. So that a line that meets all these criteria is drawn, the optimum filler composition ratio at 24 hours RSI of cement versus 60% husk ash + 40% water hyacinth ash is 75:25.

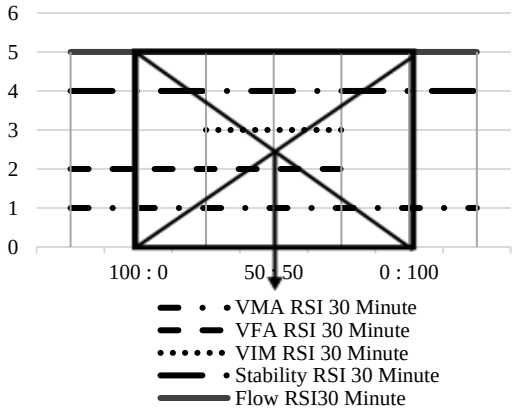


Figure 1. Optimum filler level with composition of cement filler compared 60% of husk ash filler & 40% of hyacinth filler at 30 minutes RSI, optimum filler level with composition of cement filler at 24 hours RSI [20]

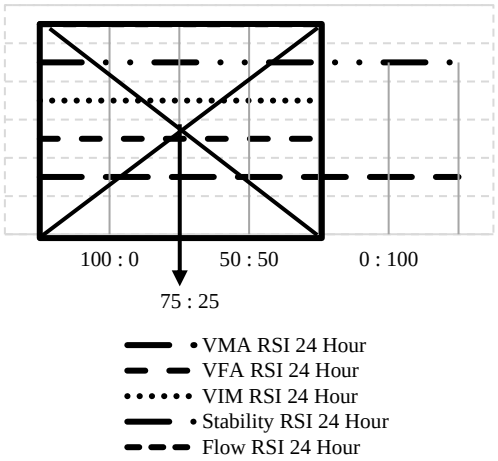


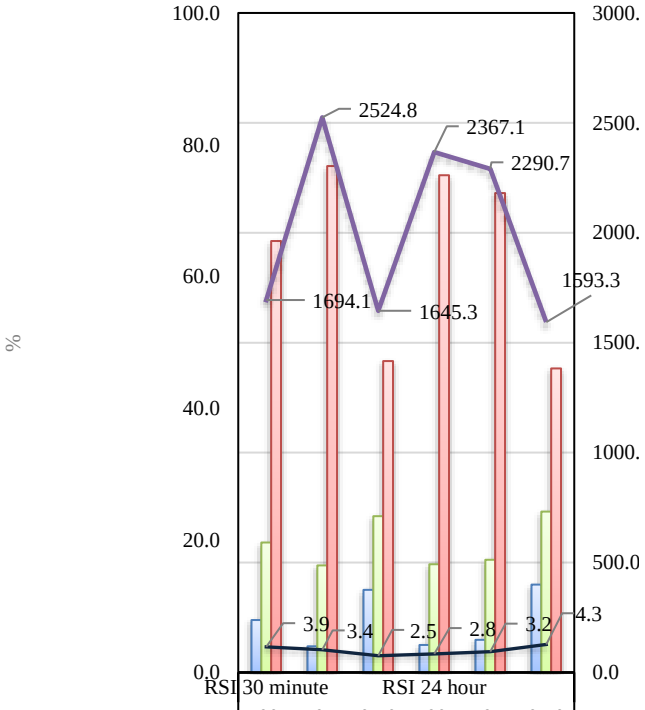
Figure 2. Optimum filler level with composition of cement filler compared 60% of husk ash filler & 40% of hyacinth filler at 24 hours RSI [20]

3.1.3. Result Marshall test with Cement Filler Compared on RSI 30 Minutes and RSI 24 Hour [20]

Marshall test with cement filler is shown in Figure 3.

3.2. Discussions

Based on the results it can be seen Figure 3 of the tests carried out in the laboratory of the DKI Jakarta Highways Department, the conclusions were drawn, namely:
1. Marshall Test Results to get Optimum Asphalt Content
a) VMA test with a level of 5%, 13.773% was obtained so that the object being tested did not meet the requirements of SNI with a minimum of 15%.
b) VMA test with a level of 6%, 15.213% was obtained so that the object being tested met the requirements of SNI with a minimum of 15%.
c) VMA test with a level of 6.5%, 17.988% was obtained so that the object being tested met the requirements of SNI with a minimum of 15%.
d) VFA test with a level of 5%, it was obtained 73.473% so that the object being tested met the requirements of SNI with a minimum of 65%.
e) VFA test with a level of 6%, it was obtained 78.808% so that the object being tested met the requirements of SNI with a minimum of 65%.



	RSI 30 minute			RSI 24 hour		
	100:1	50:50	0:100	100:1	50:50	0:100
VIM (%)	8.0	4.0	12.5	4.2	4.9	13.3
VMA (%)	19.7	16.2	23.7	16.4	17.1	24.4
VFA (%)	65.4	76.8	47.2	75.4	72.7	46.1
Flow (mm)	3.9	3.4	2.5	2.8	3.2	4.3
Stability (Kg)	1694.12	524.81	645.32	367.12	290.71	593.3

Figure 3. Marshall test with cement filler compared to 60% of husk ash & 40% of hyacinth on RSI 30 minutes and RSI 24 hours [20]

f) VFA test with a level of 6.5%, 71.233% was obtained so that the object being tested met the requirements of SNI with a minimum of 65%.
g) VIM test with a level of 5%, it was obtained 3.721% so that the object being tested met the requirements of SNI with a minimum of 3% and a maximum of 5%.
h) VIM test with a level of 6%, 3.226% is obtained so that the object being tested meets the requirements of SNI with a minimum of 3% and a maximum of 5%.
i) VIM test with a level of 6.5%, it was obtained 5.360% so that the object being tested did not meet the requirements of SNI with a minimum of 3% and a maximum of 5%.
j) The Stability test with a level of 5% obtained 1918.2 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
k) The Stability test with a level of 6% obtained 2357.7 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
l) The Stability test with a level of 6.5% obtained 2146.7 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
m) The melting test with a level of 5% obtained 2.84 mm so that the object being tested meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
n) The melting test with a level of 6%, it was obtained 2.43 mm so that the object being tested met the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
o) The melting test with a level of 6.5% obtained 2 mm so that the object being tested meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
p) Marshall test results obtained Optimum Asphalt Content (CAO) with cement filler and soaking for 30 minutes is 6.2%.

2. Marshall Test Results using 6.2% Optimum Asphalt Content with cement filler compared to 60% husk ash and 40% water hyacinth ash at RIS 30 minutes to get the Optimum Filler Content:

a) VMA test with a composition of 100:0 obtained 19.708% so that the object being tested meets the requirements of SNI with a minimum of 15%.
b) VMA test with a composition of 50:50 obtained 16.235% so that the object being tested meets the requirements of SNI with a minimum of 15%.
c) VMA test with a composition of 0:100 obtained 23.701% so that the object being tested meets the requirements of SNI with a minimum of 15%.
d) VFA test with a composition of 100:0, 65.411% of the objects tested meet the requirements of SNI with a minimum of 65%.
e) VFA test with a 50:50 composition, 76.772% of the objects tested meet the requirements of SNI with a minimum of 65%.
f) VFA test with a composition of 0:100, 47.213% of the objects tested did not meet the requirements of SNI with a minimum of 65%.
g) VIM test with a composition of 100:0 obtained 7.953% so that the object being tested does not meet the requirements of SNI with a minimum of 3% and a maximum of 5%.
h) VIM test with a composition of 50:50, 3.972% was obtained so that the object being tested met the requirements of SNI with a minimum of 3% and a maximum of 5%.
i) VIM test with a composition of 0:100, 12.530% was obtained so that the object being tested did not meet the requirements of SNI with a minimum of 3% and a maximum of 5%.
j) The Stability test with a composition of 100:0 obtained 1694.14 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
k) The Stability test with a composition of 50:50 obtained 2524.78 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
l) The Stability test with a composition of 0:100, 1645.29 kg was obtained so that the object being tested met the requirements of SNI with a minimum of 800 kg.
m) The melting test with a composition of 100:0 obtained 3,887 mm so that the object being tested meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
n) The melting test with a composition of 50:50 obtained 3,443 mm so that the object being tested meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.

o) The melting test with a composition of 0:100 obtained 2,537 mm so that the object being tested meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
p) Marshall test results obtained Optimum Filler Level with a composition of 50:50 (cement filler compared to 60% rice husk ash filler and 40% water hyacinth ash filler) at RSI 30 minutes.
3. Marshall Test Results using 6.2% Optimum Asphalt Content with cement filler compared to 60% husk ash and 40% water hyacinth ash at RSI 24 hours to get the Optimum Filler Content:
a) VMA test with a composition of 100:0 obtained 16.412% so that the object being tested meets the requirements of SNI with a minimum of 15%.
b) VMA test with a composition of 50:50 obtained 17.090% so that the object being tested meets the requirements of SNI with a minimum of 15%.
c) VMA test with a composition of 0:100 obtained 24.396% so that the object being tested meets the requirements of SNI with a minimum of 15%.
d) VFA test with a composition of 100:0, 75.381% of the objects tested meet the requirements of SNI with a minimum of 65%.
e) VFA test with a 50:50 composition, 72.679% of the objects tested meet the requirements of SNI with a minimum of 65%.
f) VFA test with a composition of 0:100, 46.096% of the objects tested did not meet the requirements of SNI with a minimum of 65%.
q) VIM test with a composition of 100:0 obtained 4.174% so that the object being tested meets the requirements of SNI with a minimum of 3% and a maximum of 5%.
r) VIM test with a composition of 50:50 obtained 4.952% so that the object being tested meets the requirements of SNI with a minimum of 3% and a maximum of 5%.
s) VIM test with a composition of 0:100, 13.327% was obtained so that the object being tested did not meet the requirements of SNI with a minimum of 3% and a maximum of 5%.
g) The Stability test with a composition of 100:0 obtained 2367.066 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
h) The Stability test with a composition of 50:50 obtained 2290.73 kg so that the object being tested meets the requirements of SNI with a minimum of 800 kg.
i) The Stability test with a composition of 0:100, 1593.296 kg was obtained so that the object being tested met the requirements of SNI with a minimum of 800 kg.
j) The melting test with a composition of 100:0 obtained 2.817 mm so that the object being tested meets the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
k) The melting test with a composition of 50:50, 3.160 mm was obtained so that the object being tested met the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
l) The melting test with a composition of 0:100, it was obtained 4,250 mm so that the object being tested did not meet the requirements of SNI with a minimum of 2 mm and a maximum of 4 mm.
m) Marshall test results obtained Optimum Filler Content with a composition of 75:25 (cement filler compared to 60% rice husk ash filler and 40% water hyacinth ash filler) at IKS 24 hours.

Table 1. Results of Residual Strength Index (RSI) [20]

Cement Filler compared 60% of Husk Ash Filler & 40% of Hyacinth Filler	Stability value		RSI (%)	Standard
	30 Min	24 hours		
100 : 0	1694.13	2367.06	139.7	>75%
50 : 50	2524.78	2290.73	90.7	
0 : 100	1645.289	1593.296	96.8	

5. Wheel Tracking Test Result

From the Marshall test, the maximum density of Optimum Asphalt Content (CAO) was obtained as a reference for making dynamic stability test specimens using Wheel Tracking.

Table 2. Results of testing wheel tracking filler cement [20]

Time	Passing	Displacement	Unit
0	0	0	mm
1	21	2.99	mm
5	105	6.05	mm
10	210	8.35	mm
15	315	10.07	mm
30	630	14.06	mm
45	945	17.04	mm
60	1260	19.49	mm
DO (Deformation During Consolidation)		9.69	mm
DS (Dynamic Stability)		257.1	Track/mm
RD (Deformation Speed)		0.1633	mm/minutes

Table 3. Wheel tracking test results with a composition of 50:50 (cement filler compared 60% rice husk ash and 40% hyacinth ash) [20]

Time	Passing	Displacement	Unit
0	0	0	mm
1	21	2.99	mm
5	105	6.19	mm
10	210	8.59	mm
15	315	10.2	mm
30	630	14.19	mm
45	945	17.26	mm
60	1260	19.76	mm
DO (Deformation During Consolidation)		9.9	mm
DS (Dynamic Stability)		218.1	Track/mm
RD (Deformation Speed)		0.1736	mm/minutes

4. CONCLUSIONS

Rice husk ash and hyacinth ash can be used as cement replacement fillers because they meet the requirements of SNI. From the results of the filler test that the filler can be used for flexible pavement because it has a high stability value. From the results of asphalt testing, that asphalt has good quality because it meets the requirements of SNI. From the Marshall test results, the asphalt mixture with cement filler composition compared with 60% of rice husk ash filler and 40% water hyacinth ash filler (50:50) has good mixed stability because it has a higher value compared to cement mixture in 30 minutes immersion and soaking 24 hours with a temperature of 60 °C. From the Residual Strength Index (RSI) all specimens is below requirement that all specimens meets the requirements. From the results of Dynamics stability testing using the Wheel Tracking tool in this study that the mixture of Laston AC-WC uses a cement filler composition compared to 60% of rice husk ash filler and 40% of hyacinth ash filler (50:50) smaller DS (Dynamic Stability) that is 218.1 track / mm compared to the mixture of Laston AC-WC using a 257.1 track / mm cement filler. From the two Wheel Tracking test results it can be concluded that the mixture of flexible pavement does not meet the requirements, because the Dynamic Stability value is below 2500 track / mm

NOMENCLATURES

1. Acronyms

DKI : Daerah Khusus Ibukota / Special Capital Region
KAO: Kadar Aspal Optimum / Optimum Asphalt Level / CAO
TFOT: Thin Film Over Test
IKS: Index Kekuatan Sisa / RSI / Residual Strength Index
mm: millimeter
SNI: Standard Nasional Indonesia / Indonesian National Standard
Kg: Kilogram

REFERENCES

[1] M. Kamil, R. Anggraini, F.M. Suryani, "The Performance of Asphalt-Concrete Wearingcourse (AC-WC) Mixture by Using Rice Husk Ash as Filler with the Addition of Asbuton in Asphalt Pen 60/70 as Binder", The Annual International Conference, Syiah Kuala University, 2011 Banda Aceh, Indonesia, pp. 173-182, 29-30 November 2011.

[2] G.W. Mbugua, H.M. Mbuvi, J.W. Muthengia, "Rice Husk Ash Derived Zeolite Blended with Water Hyacinth Ash for Enhanced Adsorption of Cadmium Ions", Current World Environment, Issue 2, Vol. 9, pp. 280-286, 2014.

[3] J.D. Woodward, J.C. Morris, Z. Khan, "Accuracy of Stone Casts Produced by Perforated Trays and Nonperforated Trays", The Journal of Prosthetic Dentistry, Issue 3, Vol. 53, pp. 347-350, March 1985.

[4] W.D. Callister, D.G. Rethwisch, "Materials Science and Engineering: An Introduction, 10th Austra", John Wiley & Sons, Inc, USA, pp. 92-120, 2018.

[5] J.W. Wilde, "New Concepts in Technical Trading Systems", Trend Research, Greensboro, N.C., pp. 63-70, 1978.

[6] A. Setyawan, Djumari, S.J. Legowo, B. Widiharjo, A. K.S. Zai1, A.A.W. Pradana, I.P. Rusadi, A. Permana, "Design and Characterization of Renewable Bioasphalt Containing Damar Resin, Fly Ash, Wasted Cooking Oil and Latex", IOP Conference Series: Materials Science and Engineering, Vol. 176, International Conference on Advanced Materials for Better Future 20163-4 October, 176 012027, pp. 1-6, 2016.

[7] J. Bolden, T. Abu Lebdeh, E. Fini, "Utilization of Recycled And Waste Materials In Various Construction", Applications American Journal of Environmental Science, Issue 1, Vol. 9, pp. 14-24, 2013.

[8] Fadhilah, H. Prabowo, T. Saldi, "The Feasibility Test of Physical and Chemical Peoperties of Muaro Binguang Pasaman Barat Iron Sand for Semen Padang", Journal of Physics: Conference Series, 1594 012037, pp. 1-6, 2020.

[9] SNI 8198: 2015 Specifications Continuous Graded Hot Paved (Laston), Jakarta: National Standardization Agency, 2015.

[10] S. Silvia, "Hot Mixed Asphalt Concrete", Bandung: Granite, pp. 1-112, 2003.

[11] N. Widyaningsih, B. Sutanto, "Influence of Plant Hyacinth as Filler on Mixed AC-WC (Asphalt Concrete - Wearing Course) with Marshall Test", IOP Conference Series: Materials Science and Engineering, pp. 1-9, 2018.

[12] H.T. Tham, N.V. Man, T. Pauly, "Fermentation Quality of Ensiled Water Hyacinth (Eichhornia Crassipes) as Affected by Additives", Asian-Aust. J. Anim. Sci., Issue 2, Vol. 26, pp. 195-201, 2013.

[13] F.Z. Derias, M.M. Mehdi, Z. Lounis, "Quantitative And Qualitative Characterization of Municipal Solid Waste In Western Algeria: Impact of Population Growth International", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 45, Vol. 12, No. 4, pp. 28-35, December 2020.

[14] N. Widyaningsih, R.K. Viandini, "Effect of Glass Powder and Husk Ash Filler on Pavement with Marshall Test Using Warm Mix System on AC-WC", International Journal of Civil and Structural Engineering Research (IJCSER), Issue 1, Vol. 6, pp. 142-147, 2018.

[15] M. Anwar, T. Miyagawa, M. Gaweesh, "Using Rice Husk Ash as a Cement Replacement Material in Concrete", Waste Management Series, Vol. 1, pp. 671-684, 2000.

[16] M.C. Nyawira, "Analysis of Heavy Metal Content in Water Hyacinth (Eichhornia Crassipes) From Lake Victoria and Assessment of its Potential as A Feedstock for Biogas", Thesis, Master of Science in Nuclear Science, University of Nairobi, pp. 28-41, 2016.

[17] R. Makofane, "Evaluation of Water Hyacinth (Eichhornia Crassipes) Suitability as Feedstock for Biogas", Thesis, Master of Science in Environmental Science, University of South Africa, pp. 7-28, 2018.

[18] A. Lakhdar, A. Moumen, Z. Laabid, Kh. Mansouri, "Mechanical Behavior of Flexible Recycled PVC Bio-Loaded By 10% Chicken Feathers", International Journal on Technical and Physical Problems of Engineering

(IJTPE), Issue 48, Vol. 13, No. 3, pp 14-19, September 2021.
[19] D.D.M. Huwae, L.R. Parera, Alpius, J. Tanijaya, "The Use of Natural Sand from Lampu Satu Beach, Merauke Regency, Papua for Mixed Asphalt Concrete", IOP Conf. Ser., Mater. Sci. Eng., 204 012022, pp. 1-5, 2017.
[20] M.H. Afadil, "Identification of Asphalt Mixed Stability Value with Rice Husk Ash and Water Hyacinth on Mixed AC-WC Using Test Method Marshall and Wheel Tracking", Thesis, Department of Civil Engineering, Engineering Faculty, University of Mercu Buana, Jakarta, Indonesia, pp. IV.1-IV-47, 2020.

ACKNOWLEDGEMENTS

This research is fully supported by University of Mercu Buana and University of Kebangsaan Malaysia as a Joint Research Collaboration Overseas. The authors owe their gratitude to all those people who have made this work possible and because of whom their experiences have been one that they will cherish forever.

BIOGRAPHIES

Nunung Widyaningsih was born in Indonesia on January 4, 1959. She received a degree in Civil Engineering from University of Gadjah Mada, Indonesia in 1987, Postgraduate Diploma Engineering form Institute for Transport Studies, Indonesia in 1995 and the Ph.D. degree from Tarumanagara University, Indonesia in 2013. She is a senior lecturer at the Master of Civil Engineering in Engineering Faculty of Mercu Buana University, Jakarta, Indonesia. Since 2006, she presents as corresponding and responsible for this research as well. She is a lecturer in Transportation Engineering for Undergraduate Studies and a Traffic Control Engineering, Transport Modelling and Mathematics for Postgraduate Studies. She is a reviewer in journal of Civil Engineering as Sinta 5 in Department of Civil Engineering and Journal of Sinergi as Sinta 2 for Engineering Faculty of Mercu Buana University (Sinta is Government ranking journal in Indonesia), Indonesia. She is the reviewer in Journal of Engineering Research and Sciences and also research for young lecturer. She has authored or co-authored of several papers) in the Scopus journals. She is a member of organization of Engineering in Indonesia. Her research interests are transport demand, pavement, transport infrastructure and traffic engineering.

Wan Hanna Melini Binti Wan Mohtar was born in Selangor, Malaysia on September 9, 1980. She received B.Eng. (Hons.) degree in Civil and Structural from University of Kebangsaan Malaysia, Selangor, Malaysia in 2002, M.Sc. and M.Eng. degree from Korea Institute of Science Technology, Seoul, South Korea in 2005 and Ph.D. degree from University of Nottingham, UK in 2011. She is currently a Senior Lecturer at Department of Civil and Structural Engineering, University of Kebangsaan Malaysia since 2012. She has authored of several papers (over to 100) in journals (ISI/INSPEC or indexed) and international conference proceedings. She is the member of several scientific organizations. Her research interest is sediment transport, environmental hydraulics.

Nur Izzi Bin Md Yussof was born in Kelantan, Malaysia on 25 April 1980. He received the B.Eng. (Hons) degree in Civil and Structural Engineering from University of Kebangsaan Malaysia, Selangor, Malaysia in 2002. He received the M.Sc. degree in the field of Highway and Transportation Engineering from Technological University of Malaysia and Ph.D. degree from University of Nottingham, UK in 2012. He is an Associate Professor of Civil and Structural Engineering at University Kebangsaan Malaysia. He has authored of several papers (over to 100) in journals (ISI/INSPEC or indexed) and international conference proceedings. He is member of several scientific organizations. His specialization is Asphalt Technology. His research interest is asphalt technology.

Reni Karno Kinasih was born in Jakarta, Indonesia on 17 August 1984. She received the Bachelor degree in Civil Engineering from University of Mercu Buana, Jakarta, Indonesia in 2009 and Master in Civil Engineering from University of Indonesia, Depok, West Java and Salemba, Jakarta, Indonesia in 2014. She is a junior lecturer in Civil Engineering and also the secretary of Master of Civil Engineering in Engineering Faculty of Mercu Buana University, Jakarta, Indonesia. Her research interests are traffic engineering, pavement design and policy transportation.