NASKAH PUBLIKASI (*MANUSCRIPT)*

ANALISIS VOLUMETRIK BETON ASPAL DENGAN *FILLER FLY ASH* DAN *FILLER* LIMBAH SERBUK KACA TERHADAP GENANGAN AIR LAUT

VOLUMETRIC ANALYSIS OF ASPHALT CONCRETE WITH FLY ASH FILLER AND GLASSPOWDER WASTE FILLER AGAINST SEAWATER PONDING

Rusandi Noor[1], Ulwiyah Wahdah Mufassirin Liana[2], Bimantara Arya Nugraha[3], Muhammad Reza Saputra[4]

Disusun Oleh :

Bimantara Arya Nugraha

2011102443026

Muhammad Reza Saputra

2011102443028

PROGRAM STUDI TEKNIK SIPIL

FAKULTAS SAINS DAN TEKNOLOGI

UNIVERSITAS MUHAMMADIYAH KALIMANTAN TIMUR

2024

Naskah Publikasi (*Manuscript)*

Analisis Volumetrik Beton Aspal dengan *Filler Fly Ash* dan *Filler* Limbah Serbuk Kaca terhadap Genangan Air Laut

Volumetric Analysis of Asphalt Concrete with Fly Ash Filler and Glass Powder Waste Filler Against Seawater Ponding

Rusandi Noor[1], Ulwiyah Wahdah Mufassirin Liana[2], Bimantara Arya Nugraha[3], Muhammad Reza Saputra[4]

Disusun Oleh :

Bimantara Arya Nugraha

2011102443026

Muhammad Reza Saputra

2011102443028

PROGRAM STUDI TEKNIK SIPIL

FAKULTAS SAINS DAN TEKNOLOGI

UNIVERSITAS MUHAMMADIYAH KALIMANTAN TIMUR

2024

LEMBAR PERSETUJUAN

Kami dengan ini mengajukan surat persetujuan untuk publikasi penelitian dengan judul :

ANALISIS VOLUMETRIK BETON ASPAL DENGAN *FILLER FLY ASH* DAN *FILLER* LIMBAH SERBUK KACA TERHADAP GENANGAN AIR LAUT

Bersama dengan surat ini kami lampirkan naskah publikasi

Peneliti

Bimantara Arya Nugraha
NIM. 2011102443028

Peneliti

Muhammad Reza Saputra
NIM. 2011102443031

Pembimbing

Dr. Eng., Rusandi Noor, S.T., M.T
NIDN. 1101049101

Disahkan

Ketua Program Studi Teknik Sipil

Fakultas Sains dan Teknologi

Universitas Muhammadiyah Kalimantan Timur

Dr. Eng., Rusandi Noor, S.T., M.T
NIDN. 1101049101

LEMBAR PENGESAHAN

ANALISIS VOLUMETRIK BETON ASPAL DENGAN *FILLER FLY ASH* DAN *FILLER* LIMBAH SERBUK KACA TERHADAP GENANGAN AIR LAUT

NASKAH PUBLIKASI

Disusun Oleh :

Bimantara Arya Nugraha

NIM. 2011102443026

Muhammad Reza Saputra

NIM. 2011102443028

Telah diseminarkan dan diujikan

Pada tanggal 16 Januari 2024

Dewan Penguji :

Ulwiyah Wahdah Mufassirin Liana, S.T., M.T
NIDN. 112402901
(Dewan Penguji I) ....

Dr. Eng., Rusandi Noor., S.T., M.T
NIDN. 1101049101
(Dewan Penguji II) ....

Disahkan

Ketua Program Studi Teknik Sipil

Fakultas Sains dan Teknologi

Universitas Muhammadiyah Kalimantan Timur,

UNIVERSITAS MUHAMMADIYAH KALIMANTAN TIMUR PROGRAM STUDI TEKNIK SIPIL

Dr. Eng., Rusandi Noor., S.T., M.T

NIDN. 1101049101

Volumetric Analysis of Asphalt Concrete with Fly Ash Filler and Glass Powder Waste Filler against Seawater Puddles

Rusandi Noor[1] *, Bimanatara Arya Nugraha[1], Muhammad Reza Saputra[1]
[1] Civil Engineering Study Program, Faculty of Science and Technology, University of Muhammadiyah East Kalimantan, Jl Juanda No 15, Samarinda
* Corresponding Email: rn903@umkt.ac.id

Abstract –
This study investigated volumetric analysis on asphalt concrete mixtures containing fly ash filler and glass powder waste filler, focusing on the response to local inundation of seawater. This study investigated volumetric analysis on asphalt concrete mixtures containing fly ash filler and glass powder waste filler, focusing on response to local inundation of seawater which includes Stability, Flow, VIM, VMA, and VFB. In the 4-day seawater puddle model cycle, 12 specimens were made: 3 fly ash fillers, 3 glass powder waste fillers, and 3 normal asphalt, tested for 5 hours and 10 hours. This study explores the impact of fillers and inundation cycles on asphalt concrete characteristics. To realize the model of seawater puddles, in cylindrical specimens PVC retaining rings of the same diameter as the specimen (100 mm) are used tightly covered with silicone on the specimen surface. Filler with glass powder has low hygroscopic properties, which can help reduce moisture absorption in asphalt mixture beyond filler with fly ash. This can reduce the risk of changes in mechanical properties due to high water content. This study can provide an analysis of how well the asphalt mixture is able to withstand moisture and the extent to which glass powder filler and fly ash filler affect the absorbency of the mixture.

Keywords: Analysis Volumetric, Fly Ash, Glass Powder, VIM, VMA, VFB

1. Introduction

Fly ash is a commonly available industrial waste and can be used as an environmentally friendly filler in asphalt mixtures. Using fillers that have pozzolan properties is a very advantageous option to improve the stability of AC-WC asphalt. Fly ash from Class C coal, for example, is a non-organic and non-plastic material that can act as a filler in AC-WC asphalt mixtures.

Asphalt AC-WC, which stands for Asphalt Concrete Wearing Course, is the topmost layer of asphalt in a flexible pavement structure. It's the layer that comes into direct contact with vehicle tires and the environment, making it crucial for providing a smooth, safe, and durable driving surface. When mixed with asphalt, this filler turns into a suspension and forms a matrix that together with the asphalt, binds all aggregate materials in the asphalt mixture. This fly ash has pozzolanic characteristics and the ability to harden and increase strength when it reacts with water, so it is self-cementing.

The use of fly ash as a filler in the face of saltwater puddles is still not fully understood. Previous research has shown that the use of fly ash filler in asphalt mixtures can improve the performance of asphalt mixtures, especially in terms of stability, wear resistance, and crack resistance. Research conducted by [1], found a high level of stability with a small optimum level of asphalt with 4% fly ash as a filler mixture compared to normal asphalt mixture and at 4.5% KAO. The experiment also concluded that the use of fly ash filler as a filler provides significant strength compared to conventional rock ash fillers. Furthermore, the application of fly ash in asphalt mixtures has not been widely studied. There are several studies showing the use of fly ash as a filler in asphalt mixtures because its chemical character can increase adhesion between asphalt and aggregate. SiO2 and Al2O3 are the main chemical components that make up fly ash [2]. Studies conducted by [3] also prove fly ash can improve performance from conventional asphalt. Research conducted by [4]. A mixture of glass powder filler with almost the same level of stability as conventional asphalt was found by [5] as much as 6% at KAO 6.53% and KAO 7.03%. The mixture using 6% glass powder filler at 6.5% KAO produces a mixture with a level of stability almost the same as conventional asphalt.

Scrap glass is considered one of the most important parts of waste material collected, which does not include metal and inorganic materials [6]. In addition, higher flow and stability are obtained when glass powder is used to

e-ISSN: 2723-3944

replace limestone filler [7]. Glass powder also plays an important role in improving the modulus of moisture resistance and susceptibility in asphalt mixtures. [8]. Globally, glass waste production is estimated in 2020 to be around 500 million kg / day or 190 thousand tons / year [21]. However, the low porosity and smooth surface of glass particles cause some problems such as peeling, decreased shear resistance [9]. In addition, higher flow and stability are obtained when glass powder is used to replace limestone fillers [10]. On the other hand, the substitution of limestone filler with glass powder has been shown to result in increased flow and decreased stability. Glass powder also plays an important role in improving the modulus of moisture resistance and susceptibility in asphalt mixtures [11].

Based on research [12], durability can be defined as the ability of asphalt material on pavement that can withstand various environmental conditions during service conditions (traffic). The durability of asphalt refers to its ability to withstand various environmental and structural stresses over time. The characteristic of this damage is the formation of a layer that can remove the asphalt binder from the aggregate surface. In addition, research from [13] found that water scouring can add to asphalt damage. According to [14], simulates the deterioration of asphalt pavement performance in tidal environments, and shows that salt solutions have high permeability compared to fresh water, so they can seep into asphalt concrete and adversely affect its durability. According to the salty and humid environment [15], soak asphalt concrete in saline solution, and carry out dry-wet and freeze-liquid cycles to accelerate the erosion of asphalt concrete and obtain the adverse effect of salty and humid environment on asphalt concrete performance.

According to [16], revealed the mechanism of salt interaction on the durability of asphalt concrete, additionally it was found that chlorine salt solution will reduce the ability of asphalt concrete to withstand momentary elastic deformation and permanent deformation through viscoelastic analysis. According to [17], evaluated the durability of salt-based asphalt concrete with anti-acing additives and found that such additives had a detrimental effect on stability, and cracking. Therefore, asphalt concrete pavements in coastal areas often experience a decrease in durability and service life [18]. The interaction between salt and asphalt is particularly relevant in the context of road maintenance, especially in regions where de-icing salts are commonly used to combat winter ice and snow. While road salts, such as sodium chloride (table salt) or calcium chloride, are effective in preventing ice formation on road surfaces. Later [19] found that the asphalt emulsification reaction occurs when asphalt is immersed in liquid so that the use of asphalt concrete in high salt areas must use asphalt with high viscosity and aggregate with high hardness.

According to analysis [20], seawater can cause various damages to asphalt. In addition, salt in seawater can also cause shrinkage in asphalt. Asphalt concrete layer (LASTON) is a layer in highway construction, which consists of a mixture of hard asphalt and well-graded aggregate.

The location of seawater sampling is in Samboja District, Kutai Kartanegara Regency, East Kalimantan, precisely at Tanah Merah Beach Tanjung Harapan. The pickup location can be seen in Figure 1.

Figure 1. Seawater Collection Location

1.1 Salt Rate

Testing salt levels in seawater involves measuring the amount of salt or minerals dissolved in it. The use of hydrometers is a commonly used method for measuring salt levels in seawater. For example, in testing the salt content of seawater, results of 20% were obtained using a hydrometer. This means seawater has an average salt concentration of about 3.5% or equivalent to 35 grams of salt in every per-liter (1000 mL) of seawater. The salt content test can be seen in Figure 2.

Figure 2. Seawater Rate

1.1 pH Level

Testing the pH level of seawater was carried out using litmus paper, and the results showed a pH value of 6. Typically, the pH of seawater is above 7, indicating basic properties, although in certain situations, the pH may become lower than 7 signifying acidic properties [22]. Most aquatic organisms are very sensitive to fluctuations in pH, and the optimal pH value for life ranges from 7 to 8.5. The pH testing can be seen in Figure 3.

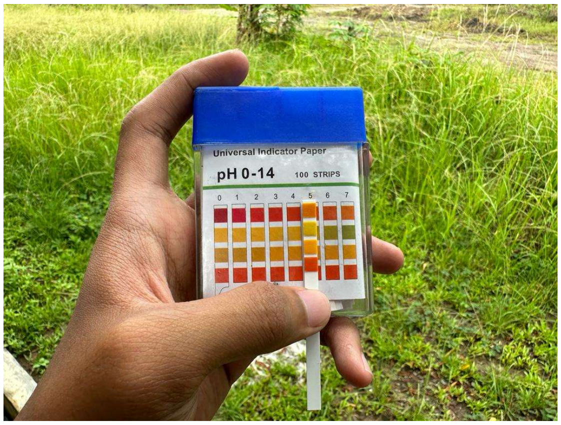


Figure 3. Seawater pH rate

2. Research Methodology

This research method begins with the collection of aggregate, fly ash filler, and glass powder waste filler, which involves the preparation of asphalt concrete, as well as seawater sampling for inundation simulation. Next, 18 asphalt concrete mixtures are made by determining the optimal proportion between these components, The asphalt used to make the sample must be in hot conditions. Mixing is carried out until the asphalt and aggregate are thoroughly mixed. Then, specimen printing is carried out using a mold with a predetermined size for volumetric testing and the mixture of asphalt and aggregate is compacted to reach the desired density. Compaction is carried out with a compaction tool corresponding to 70 collisions. After that, remove the sample from the mold and a cooling process is carried out so that the sample hardens. After that, the sample is weighed to find out the initial weight of the sample. Next, the inundation stage is carried out.

After the asphalt sample has been flooded for a specified time, 12 samples are carried out marshall testing, by inserting them into a weight weighing device in water and recording their weight, after which the samples are removed and the surface is dried to calculate the weight of the SSD by wiping the sample surface. Then, the sample is put into a water bath with a temperature of 60 ° C for 30 minutes, if it has reached 30 minutes remove the sample and conduct stability and flow testing with a marshall.

6 of the remaining 18 samples were then penetration tested to see how deep the water penetration was in the asphalt sample. By the way, the asphalt sample that has been flooded is immediately placed in the middle of the sensory machine and then cut through the upper position of the sample. After splitting into 2, the sample is examined how deep the penetration occurs.

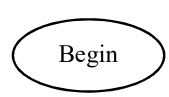
Examples of fly ash fillers and glass powder waste fillers can be seen in Figure 4. Figure 5.

Figure 4. Fly Ash Filler

Figure 5. Glass Powder Filler

2.1 Research Flow Chart

A research flow chart is a tool used to illustrate the steps or stages that will be undertaken in conducting research. This chart helps researchers to systematically plan, execute, and evaluate their research. Although the form may vary depending on the type of research and methods used. The research flow chart can be figure 6. below



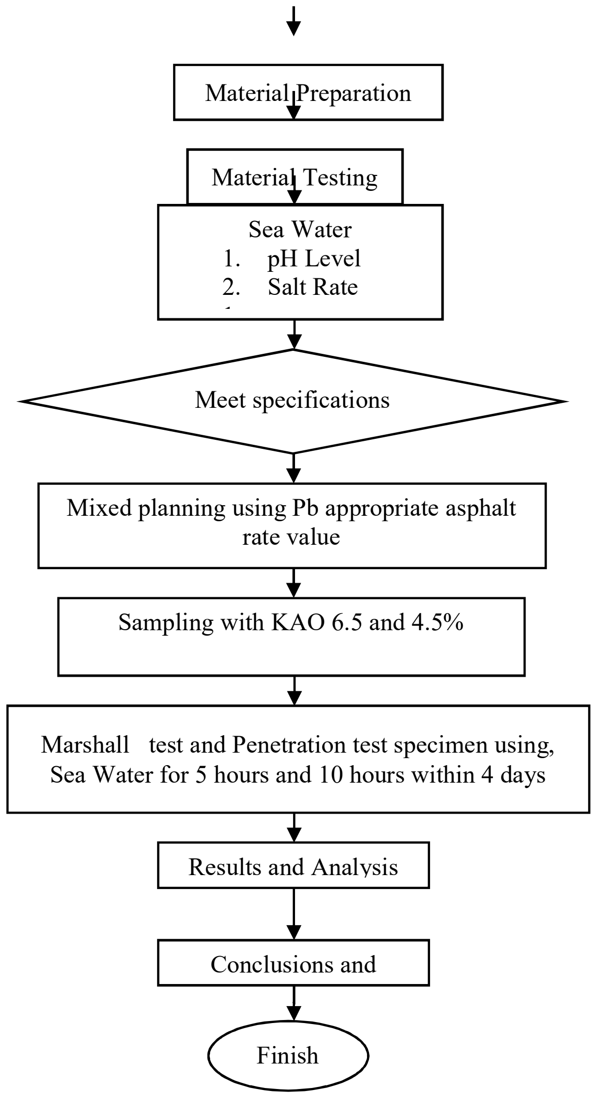


Figure 6. Research Flow Chart

For the division of specimens tested by marshalls and those performed by split tests can be seen in Table 1., Table 2. and Table 3. below.

Tabel 1. Specimen Distribution

Pengujian	5 Hours	10 Hours
Metode Marshall	6	6
Uji Belah	3	3

Tabel 2. Specimen Split Test

Jenis Filler	5 Hours	10 Hours
Normal	1 Sample	1 Sample
Serbuk Kaca	1 Sample	1 Sample
Fly Ash	1 Sample	1 Sample

Tabel 3. Specimen Marshall Method

Filler Type	5 Hours	10 Hours
Normal	2 Sample	2 Sample
Glass Powder	2 Sample	2 Sample
Fly Ash	2 Sample	2 Sample

2.1 Marshall Method

The marshall method with an absolute density approach is one of the strategies in designing AC-WC asphalt mixtures. This marshall approach applies only to hot concrete asphalt mixtures used on road surfaces, using penetrating concrete asphalt types.

This research was conducted in the laboratory of the Faculty of Science and Technology majoring in S1 Civil Engineering, University of Muhammadiyah East Kalimantan. This study used the design of a mixture of asphalt content values according to Pb, making samples with KAO 6.5% and 4.5%. Tests were carried out on both variations in asphalt content, namely 6.5% and 4.5%, by measuring the volume and specific gravity of asphalt concrete. The data obtained from this test will be analyzed to assess the difference in volumetric characteristics between the two variations in asphalt grade. The process is expected to provide in-depth insight into the effect of asphalt content on volumetric analysis of asphalt concrete, which can be useful in the development of more efficient and durable road construction.

To evaluate the effect of seawater on AC-WC asphalt material, an appropriate methodology has been adopted from the research of Giuliani et al, (2006). To realize the penetration of seawater, in cylindrically-shaped specimens PVC retaining rings of the same diameter as the specimen (100 mm) are used, tightly closed with silicone on the surface of the specimen. This study adopts the minimum height of seawater inundation that occurs flooding lasts for 4 days from January 22 to January 25, 2023 with a water height of -/+ 20-40 cm with a long flood duration of 5 hours, in Pangkalpinang City (BNPB). Two different time intervals have been considered to obtain extreme characteristics on the durability of AC-WC asphalt. (5 hours and 10 hours). These values are selected taking into account such factors as the high standing of seawater on the pavement road, that is, the speed of penetration of seawater. Visual investigation of AC-WC asphalt resistance based on possible asphalt color change and aggregate release.

2.2 Split Test Method

Furthermore, as many as 6 asphalt specimens will be split with grinding tools and analyzed to evaluate how deep seawater penetration has occurred. This measurement has been made and can be seen in Figure 7. Specimens that are split with a grinding device (split will be taken always at the same distance). The seawater penetration profile has been reconstructed and then the average penetration depth H_av each specimen is inferred by calculating the area of the penetrated part and dividing it by the diameter of the specimen itself. Then H_max local maximum penetration depth has been measured for each specimen. The test of splitting can be seen in Figure 7.

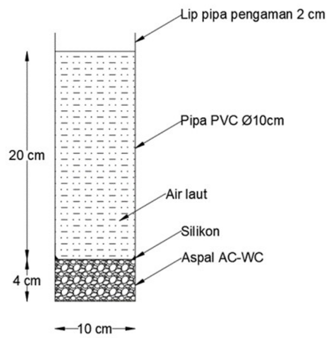


Figure 7. Example of PVC installation on specimens

3. Content and Discussion

3.1 Inspection Results of Combined Details Gradation Order

Combined Grain Gradation Arrangement Inspection (PSGBG) is a method for measuring the grain size distribution of aggregate in concrete or asphalt mixtures. Grain gradation refers to the size distribution of the particles that make up the aggregate. The purpose of PSGBG is to ensure that the concrete or asphalt mixture has a grain size distribution that matches the design specifications. The gradation table of glass powder and fly ash grains can be seen in Table 4 and Table 5.

Table 4. Glass Powder Filler

Number Sieve	3/4"	1/2"	3/8"	No.4 "	No.8 "	No.16 "	No.30 "	No.50 "	No.100 "	No.200 "	PAN
% Pass Glass Powder	100.00	95.00	83.50	61.00	43.00	30.50	22.00	15.50	10.50	6.00	0
% Pass Fly Ash	100.00	95.00	83.50	61.00	43.00	30.50	22.00	15.50	10.50	4.00	0

SOURCE : BINA MARGA 2018 REVISION 2

The specific gravity of an aggregate, in short, is the ratio between the weight of a material and the volume weight of that material. In the context of aggregates, specific gravity is often used to measure the density or density of a type of aggregate. The specific gravity table can be seen in Table 6.

Table 6. Specific Gravity

Material	Specific Gravity		
	Bulk	Apparent	Efective
	A	B	C = (A+B)/2
Coarse Agregat	2.849	2.651	2.750
Fine Agregat	2.600	2.641	2.621
Filler	2.500	2.350	2.425

Differences in characteristics in the Marshall test can occur between different asphalt mixtures and can result from several factors, These characteristic differences can result from variations in aggregate composition, asphalt type, proportion of added materials, and compaction procedure. The fly ash comparison table can be seen in Table 7.

Table 7. Comparison Characteristic Values of Marshall Filler Fly Ash

Comparison 1			
Parameter Marshall	Asphalt Content 4,5%		Specification
	Research Bimantara Arya Nugraha	Raja Mistry Tapas Kumar Roy	
VIM	6.07	4.90	>3-5
VMA	16.13	15.11	>15
VFB	62.34	74.33	>65
Stability	1838.11	1500.44	>800
Flow	4.25	3.77	>3

Asphalt mixtures with different material compositions or with different proportions of materials can produce different Marshall strength values . Marshallese strength reflects the ability of the mixture to withstand loads and axial stress. A glass powder comparison table can be seen in Table 8 and Table 9 for normal fillers

Table 8. Comparison Characteristic Values of Marshall Filler Glass Powder

Comparison 2			
Parameter Marshall	Asphalt Content 6,5 %		Specification
	Research Muhammad Reza Saputra	Yusra Aulia Sari	
VIM	4.36	3.70	>3-5
VMA	14.60	17.54	>15
VFB	70.65	78.89	>65
Stability	2245,77	2164.31	>800
Flow	4,33	3.7	>3

3.2 Marshall Test

After testing Marshall filler Fly Ash and Glass Powder, the results of the data will be analyzed with the aim of obtaining marshall characteristic values in Stability, Meltdown (Flow), Marshall Quotient (MQ), cavities in aggregate (VMA), cavities in mixtures (VIM), and cavities in bitumen (VFB). However, the deepening of the calculations is only described for VIM, VFB, and VMA which are three important parameters in the asphalt mixture. These three parameters have a significant influence on the properties of the asphalt mixture, such as strength, stickiness, and durability. A picture of VIM can be seen in Figure 7.

Void in Mix or also called void in the mixture is used to determine the size of the mixed cavity, so that the cavity is not too small which will cause bleeding which can cause oxidation or aging of asphalt with the entry of air and ultraviolet light.

For calculations can be seen in formula 1.

$$VIM = 100 \times \frac{Gmm \times Gmb}{Gmm} \quad (1)$$

1. VIM Fly Ash = 100 – (100 x g/h)
Sample 1 = Penetration test (split test)
Sample 2 = 100 – (100 x 2,376/2,531) = 6,13 %
Sample 3 = 100 – (100 x 2,379/2,531) = 6,02 %
Average = (6,13+6,02)/2
= 6.07%

2. VIM Glass Powder = 100 – (100 x g/h)
Sample 1 = 100 – (100 x 2,454/2,531) = 3,062 %
Sample 2 = Penetration test (split test)
Sample 3 = 100 – (100 x 2,388/2,531) = 5,659 %
Average = (3,062+5,659)/2 = 4,360 %

After performing Marshall testing, to obtain the value of VIM (Void In The Mix), the air cavity in the mixture. Graphic Image 7 can be seen.

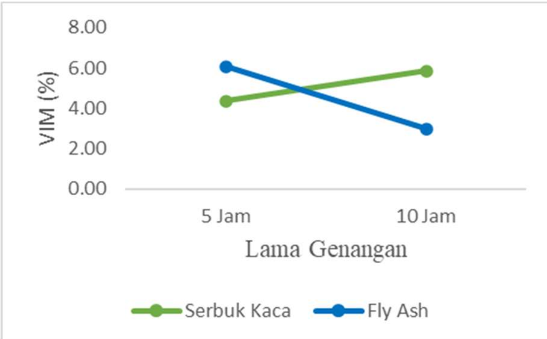


Figure 7. VIM

Based on the data in Figure 7, it was found that the VIM value of fly ash filler reached the highest value of 6.07% after inundation for 5 hours, and the lowest value of 2.99% after inundation for 10 hours. Meanwhile, glass powder filler reached the highest value of 5.86% after inundation for 10 hours, and the lowest value was 4.36% after inundation for 5 hours. It is important to note that both fillers, both fly ash and glass powder, do not meet the requirements of Bina Marga 2018 revision II which sets a value of >3.5%. In the Marshall test, the non-qualification of the VIM value can be caused by several factors, such as improper composition of asphalt mixture, such as imbalance of aggregate and asphalt proportions. In addition, damage to aggregates, such as cracks or other physical damage, can also affect the VIM value. Details of the calculation can be found in formula 1.

VMA (Void in the Mineral Aggregate) is the amount of pore volume inside each grain of aggregate in solid asphalt concrete, expressed as a percentage.
For calculations can be seen in formula 2.

VMA = 100 x $\frac{Gmb \ x \ Ps}{Gsb}$.. (2)

1. VMA fly Ash = 100 – j
Sample 1 = Penetration test (split test)
Sample 2 = 100 – 83.52 = 16.18 %
Sample 3 = 100 – 83.92 = 16.08 %
Average = (16,18+16,08)/2 = 16.13 %

2. VMA Glass Powder = 100 – j
Sample 1 = 100 – 86.56 = 13.44 %
Sample 2 = Penetration test (split test)
Sample 3 = 100 – 84.24 = 15.76 %
Average = (13,44+15,76)/2 = 14.60 %

After performing Marshall testing, to obtain VMA (Void Mineral Aggregate) values, air cavities in mineral aggregates. Can be seen Graphic Image 8.

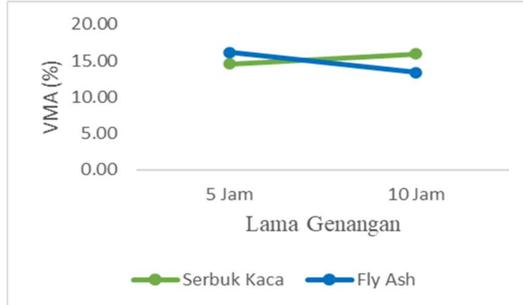


Figure 8. VMA

Based on the data in Figure 8, it was found that the VMA value of fly ash filler peaked at 16.13% after inundation for 5 hours, while the lowest value reached 13.37% after inundation for 10 hours. Meanwhile, glass powder filler reached the highest value of 15.93% after inundation for 10 hours, and the lowest value was 14.60% after inundation for 5 hours. However, it should be noted that after a 5-hour inundation of fly ash filler or glass powder after a 10-hour puddle does not meet the requirements of Highways 2018 revision II which sets a VMA value (>15%). This condition is caused by the lack of amount of asphalt in filling the cavity, which results in a lack of effectiveness of the coating in binding aggregates and causes easy pavement to be detached from the mixture. Details of the calculation can be found in formula 2.

VFB is the part of the VMA that is filled with asphalt, excluding asphalt that is absorbed by individual aggregate grains. Thus, the asphalt that fills VFB is asphalt that serves to envelop the aggregate grains in solid asphalt concrete or in other words, VFB is a percentage of the volume of solid asphalt concrete that becomes an asphalt blanket. A picture of the VFB can be seen in Figure 9.
For calculations can be seen in formula 3.

VFB = 100 x $\frac{VMA-VIM}{VMAs}$...................................... (3)

1. VFB Fly Ash = 100 x i/l
Sample 1 = Penetration test (split test)
Sampel 2 = 100 x 10,05/16,18 = 62.12 %
Sampel 3 = 100 x 10,06/16,08 = 62.57 %
Average = (62,12+62,57)/2 = 62.34 %

2. VFB Glass Powder = 100 x i/l
Sampel 1 = 100 x 10,38/13,44 = 77.22 %
Sample 2 = Penetration test (split test)
Sampel 3 = 100 x 10,10/15,76 = 64.09 %
Average = (77,22+64,09)/2 = 70.65 %

After conducting Marshall testing, to obtain VFB (Void Filled With Bitumen) values, air cavities filled with asphalt. Graphic Image 9 can be seen.

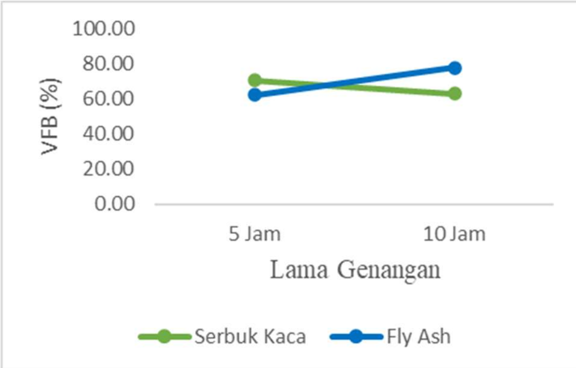


Figure 9. VFB

Based on Figure 9. VFB value of fly ash filler was obtained for the highest value of 77.91% with a puddle duration of 10 hours and for the lowest value of 62.34% with a puddle length of 5 hours. As for glass powder filler, the highest value was obtained 70.65% with a puddle duration of 5 hours and for the lowest value obtained 63.27% with a puddle duration of 10 hours. However, it should be noted that after a 5-hour inundation, neither fly ash filler nor glass powder after 10 hours of inundation do not meet the requirements of Highways 2018 revision II which sets a VFB value (>65%). Unqualified VFB values can be caused by several factors: The asphalt proposition in the mixture is too low, this can result in free space in the aggregate that is not fully filled by asphalt, so the VFB value becomes low. Conversely, if the proportion of asphalt is too high, this can result in VFB values exceeding the maximum limit. A picture of the VFB can be seen in Figure 9. For calculations can be seen in formula 3.

Asphalt stability is the ability of asphalt mixtures to withstand deformation due to fixed and repeated loads without collapsing (plastic flow). The stability of asphalt is one of the important characteristics of asphalt mixtures that determine its quality. For calculations can be seen in formula 4.

S = O x E x Q... (4)

Fly Ash Stability = P x Test specimen thickness correction (correction number)

Sample 1 = penetration test (split test)
Sample 2 = 1556.94 x 0.98 = 1527.88 Kg
Sample 3 = 1846.09 x 1.23 = 2268.38 Kg
Average = (1527,88+2068,38)/2 = 1898,13 Kg

Glass Powder Stability = P x Test specimen thickness correction (correction number)

Sample 1 = 2446.62 x 1.01 = 2464.97 Kg

Sample 2 = Penetration test (split test)
Sample 3 = 1935.05 x 1.05 = 2026.57 Kg
Average = (2464,97+2026,57)/2 = 2245,77 Kg

After performing Marshall testing, to obtain the Stability value. Graphic Image 10 can be seen.

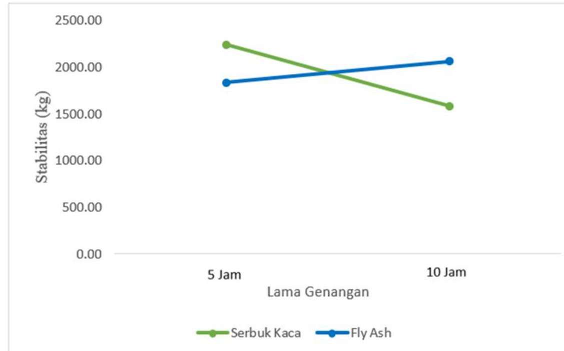


Figure 10. Stability

Based on the results of the data in Figure 10. The stability value obtained on the asphalt filler fly ash sample has met the standards of the provisions of Bina Marga 2018 revision II with the highest stability value with a value of 2064.16 kg with a puddle duration of 10 hours and the lowest value of 1838.11 kg with a puddle duration of 5 hours. While the asphalt filler glass powder sample obtained the highest value of 2245.77 kg with a puddle duration of 5 hours and the lowest value of 1584.74 kg with a puddle duration of 10 hours. The main factors affecting the stability value in the Marshall test are the composition of the asphalt mixture involving the proportion between the asphalt and the aggregate. The right balance between these two materials is crucial in determining the extent to which the asphalt mixture can withstand loads and stresses. Proportional imbalances can result in less stable mixtures, leading to low stability values in testing. In addition, the density of the mixture also plays an important role. If the density of the asphalt mixture is less, then the probability of the presence of porosity and free space in the mixture will increase, reducing the robustness and resistance of the mixture to loads. Another significant factor is the quality of materials, including aggregates and asphalt. Aggregates that are cracked or physically damaged can reduce the stability of the mixture, as well as asphalt that has inappropriate properties.Asphalt flow is one of the important factors that determine driving comfort on asphalt roads. Asphalt roads that have high flow will be more comfortable to pass, especially during heavy traffic. For calculations can be seen in formula 4.

Flow Fly Ash

Sample 1 = Penetration test (split test)
Sampel 2 = 5.00 mm
Sampel 3 = 5.25 mm
Average = (5,00+5,25)/2 = 5,13 mm

Flow Glass Powder

Sampel 1 = 3.95 mm
Sample 2 = Penetration test (split test)
Sampel 3 = 4.70 mm

Average – flat = (3,95+4,70)/2 = 4,33 mm

After performing the Marshall test, to obtain the Flow value. Figure 11 can be seen.

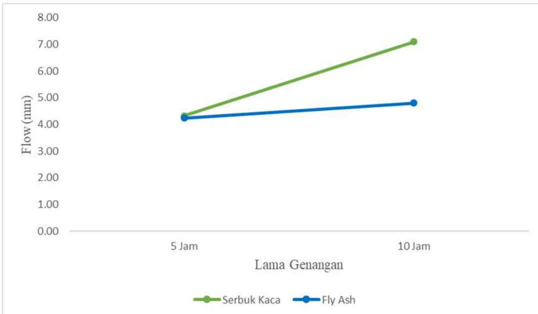


Figure 11. Flow

Based on Figure 11. The flow value in the fly ash filler asphalt sample obtained the highest value of 4.80 mm at a puddle length of 10 hours and the lowest value of 4.25 mm at a puddle length of 5 hours, while for the glass powder filler asphalt sample the highest value was obtained at 7.10 mm with a puddle duration of 10 hours and the lowest value of 4, 33 mm with a puddle duration of 5 hours. Both types of asphalt, filler, fly ash and glass powder samples have met the requirements of Bina Marga 2018 revision II with provisions of >3 mm. If the flow value is high, it will cause the pavement to be more flexible and if the flow value is low, it will cause stiffness in the road pavement.

3.3 Split Test

Seawater penetration testing, or split testing of AC-WC type asphalt samples, is an important aspect in evaluating a material's response to aggressive environments. Through this test, asphalt samples are tested against seawater penetration to assess the extent of its ability to protect road pavements from the corrosive impacts of the marine environment. The results of this split test provide insight into the level of resistance of asphalt to seawater penetration, which can provide an indication of the long-term performance of pavement in areas exposed to coastal environments.

Seawater penetration testing, or split testing of AC-WC type asphalt samples, is an important aspect in evaluating a material's response to aggressive environments. Through this test, asphalt samples are tested against seawater penetration to assess the extent of its ability to protect road pavements from the corrosive impacts of the marine environment. So the data that has been obtained can be seen in Figure 12.

3.3.1 5 Hours Sample

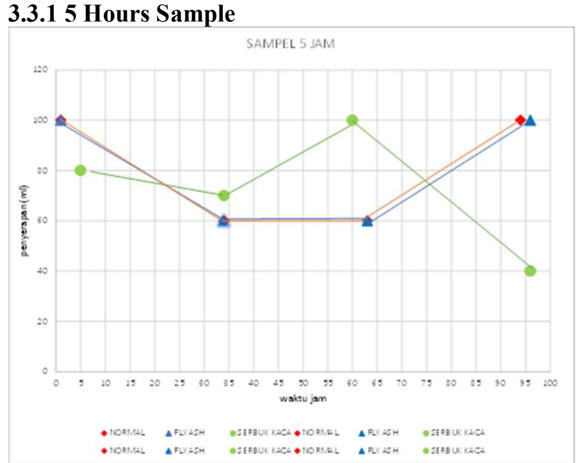


Figure 12. 5 hours Sample Chart

- On the first day, normal samples experienced water absorption of 100 ml, fly ash samples experienced absorption of 100 ml, and glass powder samples experienced absorption of 80 ml
- On the second day, normal samples experienced water absorption of 70 ml, fly ash samples experienced absorption of 70 ml, and glass powder samples experienced absorption of 60 ml
- On the third day, normal samples experienced water absorption of 60 ml, fly ash samples experienced absorption of 60 ml, and glass powder samples experienced absorption of 100 ml
- On the fourth day, normal samples experienced water absorption of 100 ml, fly ash samples experienced absorption of 100 ml, and glass powder samples experienced absorption of 40 ml

Figures 13, 14, 15, 16, 17, 18. Below is a sample sample with rock ash filler, fly ash and glass powder in a split test to see how much salt water affects the condition in the asphalt sample if it is flooded every 5 hours for 4 days.

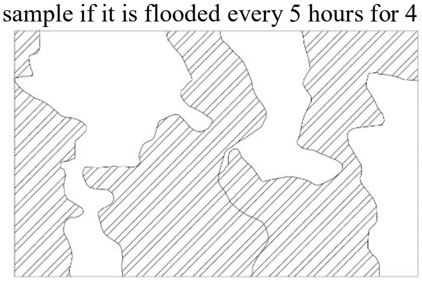


Figure 13 Glass Powder Filler Sample 5 Hours 4 Days

Figure 14. Glass Powder Filler Sample 5 Hours 4 Days

$$Glass\ Powder\ Hav = \frac{A}{D} = \frac{100}{100} = 1$$

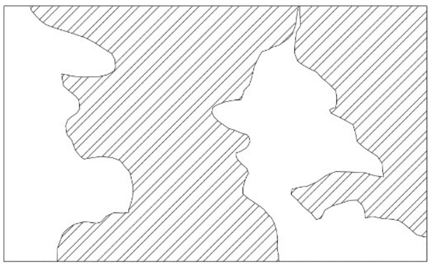


Figure 15. Stone Ash Filler Sample 5 Hours 4 Days

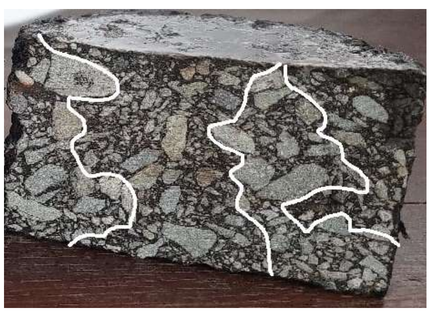


Figure 16. Stone Ash Filler Sample 5 Hours 4 Days

$$Rock\ Ash\ Hav = \frac{A}{D} = \frac{100}{100} = 1$$

Figure 17. Sampel Filler Fly Ash 5 Hours 4 Days

Figure 18. Sampel Filler Fly Ash 5 Hours 4 Days

$$Fly\ Ash\ Hav = \frac{A}{D} = \frac{100}{100} = 1$$

3.3.2 10 Hours Sample

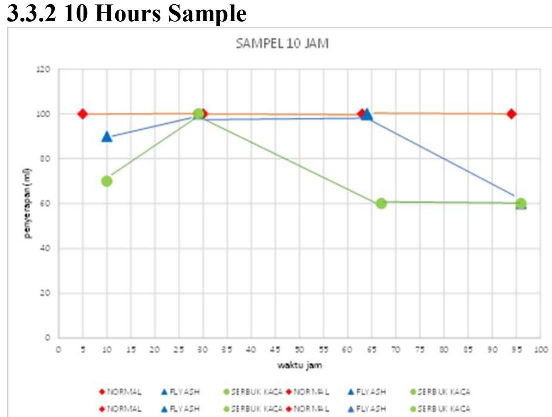


Figure 19. 10 hours Sample Chart

•On the first day normal samples experienced water absorption of 100 ml, fly ash samples experienced absorption of 90 ml, and glass powder samples experienced absorption of 70 ml

•On the second day normal samples experienced water absorption of 100 ml, fly ash samples experienced absorption of 100 ml, and glass powder samples experienced absorption of 100 ml

• On the third day, normal samples experienced water absorption of 100 ml, fly ash samples experienced absorption of 100 ml, and glass powder samples experienced absorption of 60 ml

• On the fourth day, normal samples experienced water absorption of 100 ml, fly ash samples experienced absorption of 60 ml , and glass powder samples experienced absorption of 60 ml

Figures 20, 21, 22, 23, 24, 25. Below is an example of a sample with rock ash filler , fly ash and glass powder that is split to see how much salt water affects the condition in the asphalt sample if it is flooded every 10 hours for 4 days.

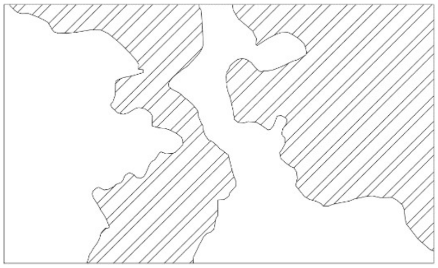


Figure 20. Glass Powder Filler Sample 10 Hours 4 Days

Figure 21. Glass Powder Filler Sample 10 Hours 4 Days

$$Glass\ Powder\ Hav = \frac{A}{D} = \frac{100}{100} = 1$$

Samples of asphalt containing glass powder may turn yellow if exposed to seawater due to chemical reactions between asphalt and certain components in seawater, especially salt (sodium chloride) and other minerals. This process is commonly known as the phenomenon of "asphalt yellowing" or yellowing on asphalt.

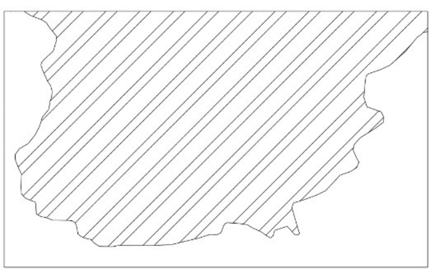


Figure 22. Stone Ash Filler Sample 10 Hours 4 Days

Figure 23. Stone Ash Filler Sample 10 Hours 4 Days

$$Rock\ Ash\ Hav = \frac{A}{D} = \frac{90}{100} = 0.9$$

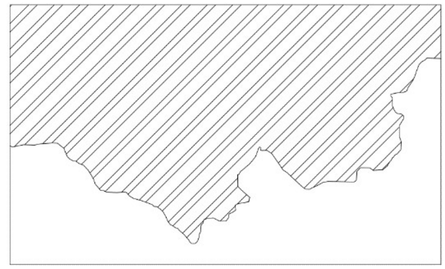


Figure 24. Fly Ash Filler Sample 10 Hours 4 Days

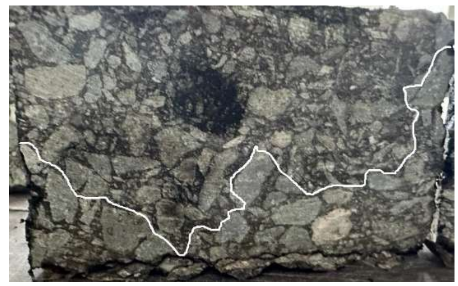


Figure 25. Fly Ash Filler Sample 10 Hours 4 Days

$$Fly\ Ash\ Hav = \frac{A}{D} = \frac{85}{100} = 0.85$$

In the data obtained for split test testing, the analysis is as follows: samples with rock ash filler and fly ash filler experience significant absorption, meaning that asphalt samples that use added rock ash filler and fly ash filler have much greater porosity than asphalt samples that use glass powder added materials, By looking at the data above, it can analyze that asphalt samples that use glass powder added materials have resistance to water levels that are above it, it can be interpreted that the porosity in the sample is much better in terms of water absorption.

Porosity in the context of asphalt or road asphalt refers to how much empty space there is between the aggregate grains in the asphalt mixture. The porosity of asphalt can affect a variety of road properties and performance, including water drainage, weather resistance, and structural strength. However, when the flooded sample experiences tidal inundation but always absorbs water, it can be analyzed that evaporation occurs in the asphalt sample. Evaporation is the process of evaporating water from an exposed surface. Water trapped inside the pores of asphalt will evaporate into the air as the temperature increases. This process will take place faster in areas that have high temperatures and low humidity.

3.3.3 The concept of voids in asphalt concrete mixture

Theoretically compacted materials such as asphalt concrete, the size of the void that occurs depends on the size and shape of the aggregate and the gradation of the aggregate formation. Similarly, in the design of mixtures using the surface area method, methods based on the percentage of voids in the mixture are more appropriate for solid graded materials (continuous gradation) than for materials,

Asphalt concrete mixture that uses open graded. In open gradation, the asphalt content used will be quite large considering that such gradation will form a thick layer / asphalt film.

The method of making asphalt concrete mixture using the concept of voids is carried out by correlating the results of experiments in the laboratory with the embodiment of the mixture in the field under actual traffic load conditions.

3.3.4 Pore Volume In Solid Asphalt Concrete Mix Aggregate (VMA)

VMA is the volume of pore inside solid asphalt concrete if the entire asphalt blanket is removed which is expressed as a percentage.

3.3.5 Volume of deep pores in solid asphalt concrete (VIM)

The number of pores in a solid asphalt concrete mixture (VIM) is the number of pores between the aggregate grains covered with asphalt and expressed as a percentage of the volume of solid asphalt concrete, VIM in asphalt samples that use filler instead of fly ash and glass powder can be seen in Figure 26 and Figure 27. Seawater contains a variety of salts, and sodium chloride is one of the dominant ones. When asphalt is exposed to seawater, there may be a reaction between the asphalt and certain salt ions that can cause discoloration. These interactions may involve oxidation and changes in the molecular structure of asphalt.

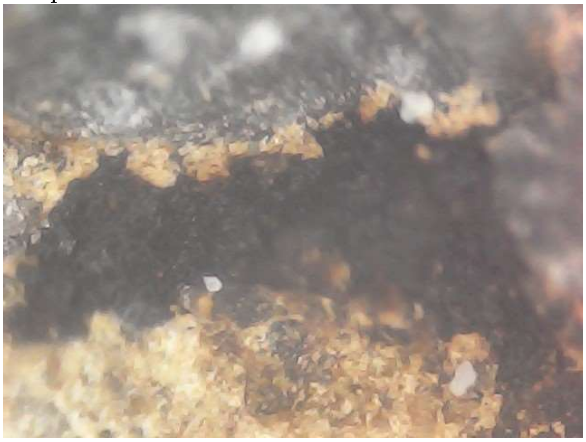


Figure 26. VIM of glass powder seen with a microscope

Figure 27. VIM fly ash viewed with a microscope

3.3.6 Pore volume between grains of asphalt filled aggregate (VFB)

The percentage of pores between aggregate grains filled by asphalt is called VFB, VFB is the part of VMA filled with asphalt which does not include asphalt absorbed by each aggregate grain.

2. Conclusion

1. Based on the results of research and data analysis above and testing can be concluded as follows:
1.Marshall VIM, VFB, and VMA Characteristic Values, from glass powder filler replacement materials with a variation of 6% filler content, VIM values with an average of 4.36% with provisions values of 3.5 – 5%, VFB values with an average of 70.65% with provisions values of 65%, VMA values with an average of 14.60% with provisions values of 16%, marshall VIM, VFB, and VMA Characteristic Values, from fly ash filler replacement materials with variations in filler content of 4%, VIM value with an average of 6.07% with a provision value of 3.5 – 5%, VFB value with an average of 62.34% with a provision value of 65%, VMA value with an average of 16.13% with a provision value of 16%, while with variations in filler levels Rock ash / Normal with variations in filler levels 6% VIM value with an average of 2.78% with a provision value of 3.5 – 5%, VFB value with an average of 79.66% with a provision value of 65%, VMA value with an average of 13.18% with a provision value of 16%.

2. The glass powder filler replacement material does not meet the Revision 2 Highways specification for VMA grades. Because the cavity space in the aggregate granules with the addition of filler is lower, the cavity is smaller and the asphalt is difficult to enter the cavity, and can cause asphalt buildup on the surface so that the aggregate will be easily released.

3. The fly ash filler replacement material does not meet the Revision 2 Highways specifications for VIM and VFB values. Due to the asphalt compaction process that is not done properly can cause vacancies or VIM that is higher than desired. Then, as we know VFB is one of the important factors to determine the quality of asphalt mixture. VFB that is too low can cause the asphalt mixture to become unstable and crack easily. VFB that is too high can cause the asphalt mixture to become not watertight and leak easily. Or during the asphalt cooking process, there is sticking with unwanted added ingredients that affect the VFB above.

Reference

[1] Mistry, R., Roy, T.K.,Effect of using fly ash as alternative filler in hot mix asphalt, Perspectives in Science(2016),http://dx.doi.org/10.1016/j.pisc.2016.04.061

[1] J. Wang, Y. Bai, H. Sui, X. Li, L. He, Understanding the effects of salinity on bitumen-calcite interactions, Fuel Process. Technol. (2020), 106668.

[2] Kringos, N., 2007. Modeling of combined physical–mechanical moisture induced damage in asphaltic mixes. Ph.D. Dissertation, Delft University of Technology, ISBN 978-90-9021765-9.

[3] 20. Sucipto, S., & Sari, Y. A. (2021). Analisa Karakteristik Campuran Aspal Menggunakan Serbuk Kaca. Journal of Civil Engineering and Planning (JCEP), 2(1), 84-98.

[4] Giuliani, F., & Rastelli, S. (2006, August). Test methods to evaluate fuel resistance of aprons asphalt pavements in airports and heliports. In Second international airports conference: planning, infrastructure & environment, Brazil.

[5] Prithvi, S. K. "Waste Materials in Hot Mix Asphalt - an Overview," National Center for Asphalt Eng. & Tech. Journal ,Vol.29, No.1, 2011 The Effect of Using Glass Powder Filler on Hot Asphalt Concrete Mixtures Properties 52 Technology, Auburn University, Alabama, 1992, pp. 10-12

[6] 19. Arabani, M. (2011). Effect of glass cullet on the improvement of the dynamic behaviour of asphalt concrete. Construction and Building Materials, 25(3), 1181-1185.

[7] . T. Pan, X. He, X. Shi, Laboratory investigation of acetate-based deicing/anti-icing agents deteriorating airfield asphalt concrete, Asph. Paving Technol. 77 (2008) 773–793.

[8] Suaryana, N., 2015. Evaluasi Stabilitas Dinamis dan Flow Number sebagai Parameter Ketahanan Campuran Beraspal Terhadap Deformasi Permanen. Pusat Litbang Jalan dan Jembatan. Bandung.

[9] Hicks, R.G., 1991. Moisture Damage in Asphalt Concrete, NCHRP Synthesis of Highway Practice 175, TRB, NRC

[10] Setiadji, B. H., & Utomo, S. (2017). Effect of chemical compounds in tidal water on asphalt pavement mixture. International Journal of Pavement Research and Technology, 10(2), 122-130.

[11] K. Zhang, Y. Luo, W. Xie, J. Wu, Evaluation of road performance and adhesive characteristic of asphalt binder in salt erosion environment, Materials Today, Communications 25 (4) (2020), 101593.

[12] Z. Zhou, H. Li, X. Liu, W. He, Investigation of sea salt erosion effect on the asphalt-aggregate interfacial system, Int. J. Pavement Res. Technol. 13 (5) (2019).

[13] J. Ma, Experimental study on performance of rubber SBS composite modified asphalt mixture under the action of salt freezing-thawing and drying-wetting cycles, Changchun Institute of Engineering.

[14] X. Ouming, X. Shunlin, Y. Xinghao, L. Yamin, Estimation of the surface free energy and moisture susceptibility of asphalt mastic and aggregate system containing salt storage additive, Constr. Build. Mater. 318 (2022).

[15] M. Zheng, J. Zhou, S. Wu, H. Yuan, J. Meng, Evaluation of long-term performance of anti-icing asphalt pavement, Constr. Build. Mater. 84 (jun.1) (2015) 277-283

[16] Q. Guo, G. Li, Y. Gao, K. Wang, Z. Dong, F. Liu, H. Zhu, Experimental investigation on bonding property of asphalt-aggregate interface under the actions of salt immersion and freeze-thaw cycles, Constr. Build. Mater. 206 (2019) 590–599.

[17] Z. Wang, T. Zhang, M. Shao, T. Ai, P. Zhao, Investigation on snow-melting performance of asphalt mixtures incorporating with salt-storage aggregates, Constr. Build. Mater. 142 (JUL.1) (2017) 187–198.

[18] Jony, H. H., Al-Rubaie, M. F., & Jahad, I. Y. (2011). The effect of using glass powder filler on hot asphalt concrete mixtures properties. Eng. Technol. J, 29(1), 44-57.

[19] T. Pan, X. He, X. Shi, Laboratory investigation of acetate-based deicing/anti-icing agents deteriorating airfield asphalt concrete, Asph. Paving Technol. 77 (2008) 773–793.

[20] Anggita D.H. (2020). Kontribusi Sampah Terhadap Pemanasan Global

[21] Sasana T. (2009). Tingkat Kasaman (pH) dan Oksigen Terlarut Sebagai Indikator Kualitas Perairan Sekitar Muara Sungai Cisandane

UMKT
UNIVERSITAS MUHAMMADIYAH
Kalimantan Timur

Kampus 1 : Jl.Ir.H. Juanda, No.15, Samarinda
Kampus 2 : Jl.Pelita, Pesona Mahakam, Samarinda
Telp: 0541-748511 Fax: 0541-766832

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

SURAT KETERANGAN ARTIKEL PUBLIKASI

Assalamu'alaikum Warahmatullahi Wabarakatuh

Saya yang bertanda tangan dibawah ini:

Nama	:	Dr. Eng. Rusandi Noor., S.T., M.T
NIDN	:	1101049101
Nama	:	Bimantara Arya Nugraha
NIM	:	2011102443026
Fakultas	:	Sains dan Teknologi
Program Studi	:	S1 Teknik Sipil

Menyatakan bahwa artikel ilmiah yang berjudul "**Analisis Volumetrik Beton Aspal dengan *Filler* Fly Ash dan *Filler* Limbah Serbuk Kaca terhadap Genangan Air Laut**" telah di submit pada JSE Journal of Science and Engineering pada tahun 2024 https://journals.umkt.ac.id/index.php/jse

Demikian surat keterangan ini dibuat untuk dapat dipergunakan sebagaimana mestinya.

Wassalamu'alaikum Warahmatullahi wabarakatuh

Samarinda, Kamis 25 Januari 2024

Mahasiswa

Bimantara Arya Nugraha
NIM. 2011102443026

Dosen Pembimbing Skripsi

Dr. Eng. Rusandi Noor., S.T., M.T
NIDN. 1101049101