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Study of the Use Bagasse Ash as a Filler Replacement to Characteristics Asphalt Concrete

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Abstract— *Asphalt concrete (AC) is a mixture of flexible road pavement divided into asphalt concrete-wearing course (AC-WC), asphalt concrete-binder course (AC-BC) and asphalt concrete-base (AC-Base) which in its use must meet the requirements set. Terms of use include having a few cavities in the aggregate structure, interlocking with one another, having high stability properties and relatively rigid. AC material consists of coarse aggragate, fine aggregate, filler and asphalt. In mixing the material is allowed to add or replace one of the materials used while still meeting the specified requirements. In this study the filler material will be tested by adding bagasse ash as a substitute or substitute material with a proportion of 25%, 50%, 75% and 100% by weight of the filler with a material composition for AC-WC Aspahlt 6.5%, Coarse Aggregate 37.05%, Fine Aggregate 50.60% and filler 5.85% while AC-BC is asphalt 6.5%, Coarse Aggregate 42.64%, Fine Aggregate 44.95% and filler 5.91%. The results showed the addition or replacement of bagasse ash into the mixture of AC-WC and AC-BC met the results of the Marshall test. Although in the analysis of the immersion index the addition of 50% is more resistant to the immersion temperature.*

Keywords— *Asphalt concrete, Bagasse ash, Marshall.*

I. Introduction

Asphalt Concrete (AC) is a layer in road construction consisting of a mixture of hard asphalt and aggregate, mixed and spread in a hot state and compacted at a certain temperature [1]. Another feature is having a little cavity in the aggregate structure, interlocking with one another, therefore concrete asphalt has high stability properties and is relatively rigid [2]. According to its function AC has 3 kinds of mixtures, namely Asphalt Concrete-Wearing Course (AC-WC), with a minimum nominal thickness is 4 cm, Asphalt Concrete-Binder Course (AC-BC), with a minimum nominal thickness is 6 cm and Asphalt Concrete-Base (AC-Base), with a minimum nominal thickness of 7.5 cm. As a surface layer of pavement, AC has structural values, is waterproof, and has high stability [2]. AC is a mixture of flexible road pavement consisting of coarse aggregate, fine aggregate, filler, and binder with certain comparisons and mixed in hot conditions. The filler material in asphalt mixture, especially AC as a road surface layer, is one of the components that has the smallest percentage besides asphalt. However, it has a very important function to modify the gradation of fine aggregate in asphalt mixture, so that the density of the mixture can increase. The filler has the function of increasing the density and stability of the mixture, increasing the number of grain contact points, reducing the number of bitumen used to fill cavities in the mixture.

According to Sukirman, there are seven mixed characteristics that must be possessed by AC are stability, durability, flexibility, fatigue resistance, skid resistance, waterproof and workability [1].

As technology develops, a lot of research has been done to maximize the stability of asphalt mixtures.

Research conducted by Himawan et al. investigated the Utilization of Sugar Cane Waste Waste as a Substitute for Filler for Concrete Asphalt Mixture Type HRS-WC [3]. Hendra et al. investigated the Effect of Addition of Sugarcane Ash Filler on Asphalt Mixes on Marshall Properties [4].

Zainudin et al., Examined the effect of Sugarcane Bagasse Ash as Filler in Hot Mix Asphalt [5]. Alamsyah researched about Utilization of Bagasse Ash of Sugar Cane as a Filler Material with Variations of Collisions in Asphalt Treated Base Mixes [6]. Kurniasari et al. investigated the effect of Sugarcane Ash Filler (AAT) Fillers with Pen 60/70 Asphalt Binder in Laston AC-WC Mixtures [7]. Huwae et al., examined the Bagasse-Ash as Filler in HRS (Hot Rolled Sheet) Mixture [8].

In this research, a study will be conducted on the Use of Sugar Cane Ash As a Substitute for Filler. In this study the filler material will be tested by adding bagasse ash as a substitute or substitute material with a proportion of 25%, 50%, 75% and 100% by weight of the filler with a material composition for AC-WC Aspahlt 6.5%, Coarse Aggregate 37.05%, Fine Aggregate 50.60% and filler 5.85% while AC-BC is asphalt 6.5%, Coarse Aggregate 42.64%, Fine Aggregate 44.95% and filler 5.91%. Which will test against the characteristics of the Laston Mix (Marshall Conventional and Marshall Immertion).

II. Methodology

The methodology used in this research is the research stage is divided into four main parts, namely preparation and testing of materials, preparation of a mixture design of AC-WC and AC-BC with and without filler replacement material, manufacture and examination of mixture characteristics and analysis of the results of the mixture testing.

A. Location

Retrieval of material to be used in this study is for coarse aggregate material, fine aggregate and rock ash taken from the Jeneberang Sungguminasa asphalt river Biliary Quari from the Road and Bridge Material Testing Laboratory of the Department of Highways (Baddoka) of the South Sulawesi Province of Indonesia and Sugarcane Bagasse from the sugar factory in Takalar district, South Sulawesi Province, Indonesia and has been dried and burned and filtered with a filter no. 200

International Journal of Scientific Engineering and Science
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B. Experimental Program

The material to be used in a mixture of AC-WC and AC-BC, must be tested in its characteristic laboratory, both aggregate and asphalt, where the test methods are based on the Indonesian National Standard (SNI) and ASTM.

- Examination of Aggregate Characteristics
  Filter Analysis (SNI 03-1968-1990), Bulk Specific Gravity and Rough Aggregate Water Absorption (SNI 1969-2008) and Fine Aggregate Bulk Bulk Absorption and Absorption (SNI 1970-2008), Sand Equivalent Test (SNI 03-4428-1997), Abration (SNI 2417: 2008), Flat and Oblong Particles (ASTM D - 4791), Aggregate Adhesion to Asphalt (SNI 2439: 2011), Material Passing Sieve No.200 (SNI 03-4142-1996), Filler Specific Testing refers to SNI reference standards 03-4142-1996.
- Asphalt Characteristics Testing
  Penetration at 250 (SNI 06-2456-1991), Flash Point and Talent Point (SNI 2433-2011), Softening Point (SNI 2434-2011), Asphalt Specific Gravity (SNI 2441-2011), Ductility 250 (SNI 2432-2011)), Lost Weight (SNI-06-2441-1991).
- Conventional Marshall Testing
  The parameters obtained in the test are Stability, Flow, Void in the Compacted Mixture (VIM), Void in the Mineral Aggregate (VMA) and Voids Filled with Bitumen (VFB).
- Marshall Immersion Test.
  The durability of the asphalt mixture is obtained from the immersion of the asphalt mixture which is carried out with different durations. The duration of immersion is 0.5 and 24 hours. After going through the water temperature immersion ± 60ºC then marshall test is performed for each specimen that has a different duration of immersion to get the stability and flow values and then calculate the durability / durability of the mixture.

C. Test Object Design

The composition of the mixture for AC-WC can be seen in Table 1.

Table 1. AC-WC Mixed Composition

Size of Sieve (Inc)	Specification (%)			Mixed Aggregate Design(%)	Mixed composition (%)	
3/4"	100	to	100	100	37.05	Coarse Aggregate
1/2"	90	to	100	95		
3/8"	77	to	90	83.5		
No.4	53	to	69	61		
No.8	33	to	53	43	50.60	Fine Aggregate
No.16	21	to	40	30.5		
No.30	14	to	30	22		
No.50	9	to	22	15.5		
No.100	6	to	15	10.5		
No.200	4	to	9	6.5		
Pan (filler)					5.85	Filler
Asphalt				6.5	6.50	Asphalt

The sieve analysis test results showed that the aggregates used as AC-WC mixture material met the specified requirements. Test results can be seen in Figure 1.

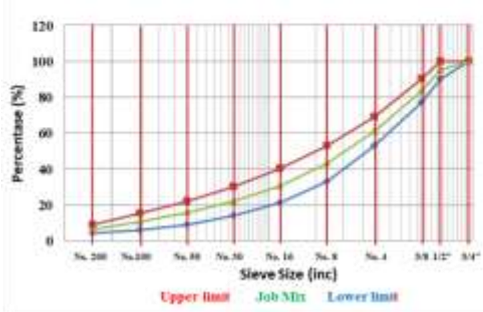

Fig. 1. AC-WC Aggregate copiment Sieve Analysis

The mixture composition for AC-BC can be seen in table 2

Table 2. AC-BC Mixed Composition

Size of Sieve (Inc)	Specification (%)			Mixed Aggregate Design(%)	Mixed composition (%)	
1"	100	to	100	100	42.64	Coarse Aggregate
3/4"	90	to	100	95		
1/2"	75	to	90	82.5		
3/8"	66	to	82	74		
No.4	46	to	64	55		
No.8	30	to	49	39.5	44.95	Fine Aggregate
No.16	18	to	38	28		
No.30	12	to	28	20		
No.50	7	to	20	13.5		
No.100	5	to	13	9		
No.200	4	to	8	6.5		
Filler					5.91	Filler
Asphalt				6.5	6.5	Asphalt

The sieve analysis test results showed that the aggregates used as AC-BC mixture material met the specified requirements. Test results can be seen in Figure 2.

Fig. 2. AC-BC Aggregate copiment Sieve Analysis

III. RESULT AND DISCUSSION

A. Aggregate Characteristics

- Aggregate wear test results obtained the value of coarse aggregate resistance to wear consisting of, fraction A is 10.6%, fraction B is 20.4%, Fraction C is 21.56% and Fraction D is 25.52%.
- Testing the density and absorption of coarse aggregates using two samples obtained the value of bulk density is 2.62, the specific gravity of SDS is 2.66, the apparent density is 2.73 and the absorption of water is 1.61%.
- The result of specific gravity and fine aggregate absorption results obtained value for bulk density is 2.58, SSD specific gravity is 2.62, apparent density is 2.69 and water absorption is 1.63%.

Volume 3, Issue 8, pp. 65-70, 2019.
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- From the test results the material passed the No. filter. 200 obtained a value of 0.6
- The aggregate test results passed the 200 fine aggregate sieve obtained a value of 0.6
- Testing of sludge content using 2 samples obtained the average results for the sand equivalent (SE) value was 96.34% and sludge content of 3.66%.
- The results of the testing of flat particles and oval coarse aggregates obtained flat particles namely 9.62%, 8.95%, 7.56%, and 0.00%. and oval particles namely 9.64%, 9.59%, 4.10% and 0.00%.

All agrgat characteristic tests meet the standard specifications.

B. Karakteristik Aspal

- Penetration testing at 25 ° C (mm) obtained a penetration value of 67.1 mm.
- Ductality test results at 25 ° C (cm) obtained an average value of 119.67cm.
- Softening point (° C) obtained an average value of 50.5 ° C
- From the flash point test results (° C) an average value of 3000 C.
- The result of specific gravity test obtained an average value of 1.044 gr / cc.
- The lost weight test results (%) obtained an average value of 0.14%.
- Penetration testing on TFOT (original%) after losing asphalt weight obtained an average value of 56.6%.

All asphalt characteristic tests meet the specifications requirements.

C. Conventional Marshal

Conventional Marshal test results on a mixture of AC-WC and AC-BC can be seen in figure 3 to figure 7.

- *Stability*

Standard specification the stability value used for AC-WC and AC-WC is 800 kg. The results of the analysis of the stability value of the levels of bagasse ash processed using the Exel program obtained the relationship as in Figure 3.

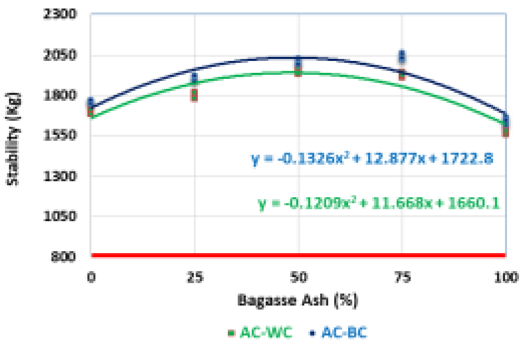

Fig. 3. Correlation between Stability with Bagasse Ash

From Figure 3 it is known that the correlation equation follows the 2nd order polynomial in which to:

Correlation Equation stability AC-WC is :

$$y = -0.1209x^2 + 11.668x + 1660.1$$

Correlation Equation stability AC-BC is :

$$y = -0.1326x^2 + 12.877x + 1722.8$$

Where: y = Stability. x = Bagasse Ash

From the AC-WC and AC-BC correlation equation the stability values are as shown in table 3.

Table 3. Mixture Stability Value

Bagasse Ash (%)	Stability (kg.)	
	AC-WC	AC-BC
0	1,660.10	1,722.80
25	1,876.24	1,961.85
50	1,941.25	2,035.15
75	1,855.14	1,942.70
100	1,617.90	1,684.50
Standard Specifications	Min. 800 kg.	Min. 800 kg.

Table 3 shows that the use of Proportion of bagasse ash will increase stability to a level of 75%, but the stability decreases again if the proportion of Ash Bagasse Ash to 100% but it is still within the requirements limits.

- Flow

From the conventional marshall characteristics test results then processed using the Exel for Windows program obtained graphs of the relationship between flow and bagasse ash levels as shown in Figure 4. The limit value used in accordance with the standard specifications for AC-WC and AC-BC is 2% to 4%.

From Figure 4 we get the correlation equation between levels of bagasse ash with flow as follows.

Correlation Equation flow AC-WC is :

$$y = 0.0002x^2 - 0.025x + 3.2338$$

Correlation Equation flow AC-BC is:

$$y = 0.0002x^2 - 0.0228x + 3.0252$$

Where : y = flow. x = Bagasse Ash

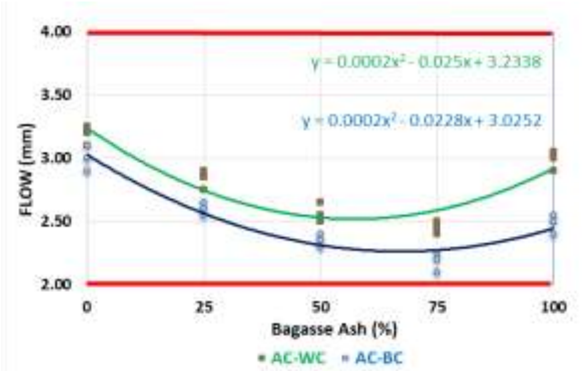

Fig. 4. Correlation between Flow with Bagasse Ash

From the correlation equation in figure 4, we get the flow values as in table 4. All flow values in the table meet the requirements.

Table 4. Value Relationship of levels of bagasse ash with Flow

Bagasse Ash (%)	Flow (mm)	
	AC-WC	AC-BC
0	3.23	3.03
25	2.73	2.58
50	2.48	2.39
75	2.48	2.44
100	2.73	2.75
Standard Specifications	**2 to 4**	**2 to 4**

from table 4 it can be seen that if the use of bagasse ash in asphalt mixes increases to 75% then the bond between the aggregates becomes strong which causes a slight flexibility. But if the use of Ash Bagasse Ash increases a lot to a proportion of 100% then the bond between the aggregates in the mixture becomes weak resulting in the flexibility of the mixture will increase, which means the strength of the mixture will be inversely proportional to the mixture flow.

- Void In The Compacted Mixture (VIM)

Correlation between VIM with Bagasse Ash can be seen in the figure 5.

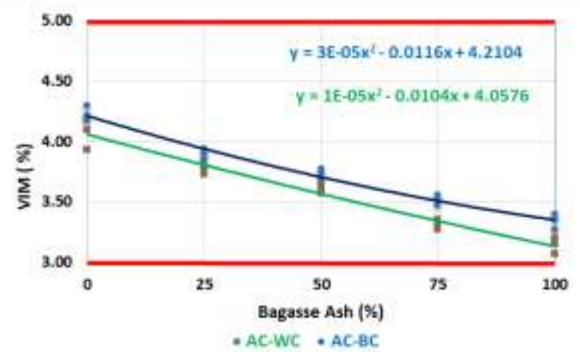

Fig. 5. Correlation between VIM with Bagasse Ash

From Figure 5 we get the correlation equation between the levels of bagasse ash with VIM as follows.

Correlation Equation VIM AC-WC is :

$$y = 1E\text{-}05x^2 - 0.0104x + 4.0576$$

Correlation Equation VIM AC-BC is :

$$y = 3E\text{-}05x^2 - 0.0116x + 4.2104$$

Where : y = VIM. x = Bagasse Ash

From the correlation equation in figure 5, we get the VIM value as in table 5. All VIM values in the table meet the requirements.

Table 5. Value Relationship of levels of bagasse ash with VIM

Bagasse Ash (%)	VIM (%)	
	AC-WC	AC-BC
0	4.06	4.21
25	3.80	3.94
50	3.56	3.71
75	3.33	3.51
100	3.12	3.35
Standard Specifications	**3 to 5**	**3 to 5**

Based on Table 5, the addition of Bagasse Ash obtained VIM values in the AC-WC mixture between 3.12% to 4.06% and AC-BC 3.35% to 44.21%. so it can be seen that the higher the proportion of bagasse Ash used, the smaller the VIM value and vice versa, if the proportion of Bagasse Ash that is used is less, the VIM value will be greater, because Bagasse Ash will help the asphalt with a function as a filler cavity in the asphalt mixture.

- *Void in the Mineral Aggregat (VMA)*

Correlation between VMA and Bagasse Ash can be seen in Figure 6. From figure 6 we get the correlation equation between levels of bagasse ash with VMA as follows.

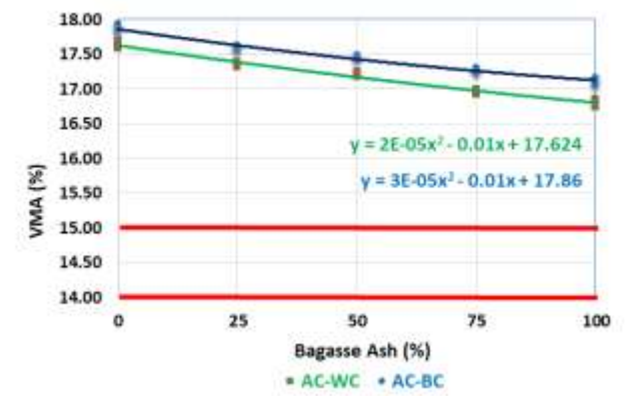

Fig. 6. Correlation between VMA with Bagasse Ash

Correlation Equation VMA AC-WC is :

y = 2E-05x2 - 0.01x + 17.624

Correlation Equation VMA AC-BC is :

y = 3E-05x2 - 0.01x + 17.86

Where : y = VMA. x = Bagasse Ash

From the correlation equation in figure 6, we get the VMA value as in table 6. All VMA values in that table meet the requirements

Table 6. Value Relationship of levels of bagasse ash with VMA

Bagasse Ash (%)	VMA (%)	
	AC-WC	AC-BC
0	17.62	17.86
25	17.39	17.63
50	17.17	17.44
75	16.99	17.28
100	16.82	17.16
Standard Specifications	**Min. 15**	**Min. 14**

Table 6 shows using the proportion of bagasse ash obtained VMA values between 16.82% to 17.62% for AC-WC and 17.16% to 17.86% for AC-BC. From the figure shows the phenomenon the greater the proportion of bagasse ash used, the VMA value decreases because VMA is influenced by the number of bagasse ash used, because asphalt has not had time to enter the cavity in the aggregate during compaction, the aggregate is first attached to the bagasse ash.

- *Voids Filled with Bitumen (VFB)*

Correlation between VFB and Bagasse Ash can be seen in Figure 7. From figure 6 we get the correlation equation between the levels of bagasse ash and VFB as follows.

Correlation Equation VFB AC-WC is :

$$y = -2E\text{-}05x^2 + 0.046x + 76.848$$

Correlation Equation VFB AC-BC is :

$$y = -0.0001x^2 + 0.0524x + 76.376$$

Where : y = VFB. x = Bagasse Ash

From the correlation equation in figure 7, we get the VFB value as in table 7. All VFB values in that table meet the requirements

The phenomenon of relationship of levels of bagasse ash with VFB Figure 7 and table 7, shows that the greater the proportion of bagasse ash instead of cement fillers, the greater the value of VFB, because bagasse ash will fill cavities, especially cavities in the mixture between aggregate particles.

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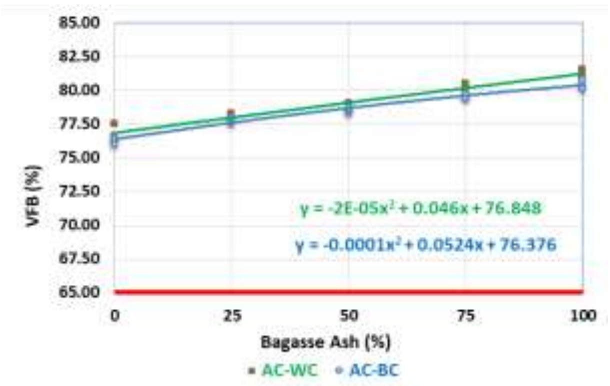

Fig. 7. Correlation between VFB with Bagasse Ash

Table 7. Value Relationship of levels of bagasse ash with VFA

Bagasse Ash (%)	VFB (%)	
	AC-WC	AC-BC
0	76.85	76.38
25	77.99	77.75
50	79.10	79.25
75	80.19	80.87
100	81.25	82.62
Standard Specifications	Min. 65	Min. 65

D. The optimum proportion of bagasse ash

Making samples for testing the immersion index uses the optimum proportion of bagasse ash. To get this, one of the most suitable proportion of bagasse ash was chosen from the results of the analysis of stability, flow, VIM, VMA and VFB [9]. From the observations all the results of the analysis meet the requirements so that in this study took the entire proportion of bagasse ash for immersion index testing.

E. Immersion index

In the immersion index test the mixture of AC-WC and AC-BC was immersed for ± 24, hour at ± 60 ° C. The immersion index was analyzed for comparison of the stability of the mixture after being immersed at a certain time duration with the stability of the immersed mixture for 0.5 hours [10]. Analysis of test results can be seen in table 8.

Table 8. Value Relationship of levels of bagasse ash with Immersion Index

Bagasse Ash (%)	Immersion Indes (%)	
	AC-BC	AC-WC
0	91.33	90.69
	92	90.97
	91.39	90.07
25	92.59	92.16
	92.55	92.5
	92.68	91.61
50	93.57	92.77
	94	93.2
	93.64	92.86
75	93.33	91.76
	93.7	92.4
	93.26	91.67
100	90.85	90.15
	91.23	90.6
	90.71	90
Standard Specifications	**90**	**90**

Marshall immersion test is a test to see the resistance of a mixture to the effects of submerged water, load and temperature immersion or durability of a mixture.

The test results obtained by the mixture of AC-WC and AC-BC increased the resistance of the mixture to the proportion of bagasse ash 50%, then decreased again to the proportion of 100%. This phenomenon explains that water can still enter the mixture but is still within tolerance limits. Based on the comparison of AC-WC and AC-BC mixture using bagasse ash in Figure 8, it is clear that the resistance of the AC-BC mixture is still greater (stronger) than AC-WC. The analysis shows that the use of bagasse ash in AC-WC and AC-BC Mixtures can still maintain mixture resistance.

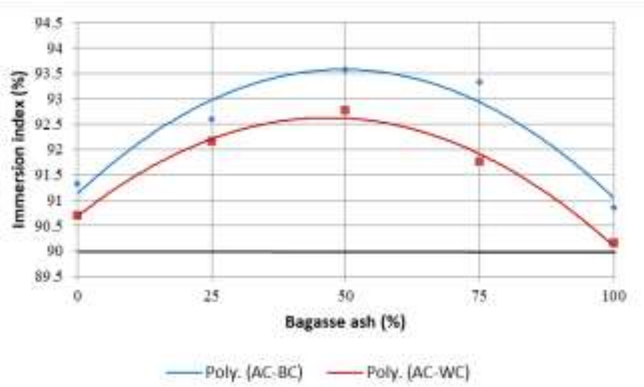

Fig. 8. Relationship of levels of bagasse ash with immersion index

IV. Conclusion

- Tests of aggregates, fillers and asphalt used for the mixture of AC-WC and AC-BC meet the requirements of standard specifications
- The use of 25%, 50%, 75% and 100% bagasse ash content in AC-WC mixtures with asphalt content of 6.5%, Coarse Aggregate 37.05%, Fine Aggregate 50.60% and filler 5.85% fulfill the conditions of use.
- The use of 25%, 50%, 75% and 100% bagasse ash content in the AC-BC mixture with asphalt content of 6.5%, Coarse Aggregate 42.64%, Fine Aggregate 44.95% and 5.91% filler fulfill the conditions of use.
- The results of the immersion index analysis of the two types of mixtures show that they can still maintain the mixture.

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