2

by Irianto Dr

VOL. 15, NO. 17, SEPTEMBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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COMPRESSIVE STRENGTH OF ASPHALT CONCRETE WEARING COURSE MIXTURE CONTAINING WASTE PLASTIC POLYPROPYLENE

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ABSTRACT

Waste plastic polypropylene is increasing due to development activities and changes in lifestyle, leading to widespread littering on the landscape. The study investigates the polypropylene waste plastic potential using an asphalt concrete modifier. The compressive strength tests conducted to examine asphalt concrete wearing course mixture strength using Modified Buton Asphalt (MBA) binder with and without waste PP (Plastic Polypropylene)based on AS-2891 standard. In these tests, mixture condition with 1% and 2% asphalt binder by total weight, were chosen as an additive for AC-WC (Asphalt Concrete Wearing Course) mixture to improve the compressive strength values. The results showed that the treated AC-WC mixture compressive strength was higher as compared to the untreated AC-WC mixture. The results denoted that waste PP can coalesce with the MBA to provide much proper binder and result in higher resistance to compressive load.

Keywords: compressive strength, AC-WC, waste PP, MBA.

1. INTRODUCTION

In recent years, much of waste plastics disposed of in the landscape. Most waste plastics, including Plastic Polypropylene (PP), are non-biodegradable material would not degrade naturally over a while, hazard posing to the environment [1-3]. Waste plastics still intact and almost unscathed after a period spent either at sea or buried underground. Waste plastics dump gained national attention due to ongoing environmental impacts [4].

In the coming years, sustainability looms as a prominent concern for a pavement industry. Decreasing waste plastics amount consistently viewed as one prominent emphasis of the sustainability movement, and waste plastics based asphalt mixture viewed as one potential alternative to providing a significant waste plastic reduction [5-6]. In pursue to address pertinent issues regarding the use of waste plastics such as waste PP in asphalt mixtures; it is imperative to grasp the influences that such additives have on ITSM properties of asphalt mixture in service [7].

In recent decades polymers have been utilized for the modification of asphalt mixture in order to alleviate the deterioration such as cracking, rutting, permanent deformation [8-11]. The utilization of virgin polymer modified asphalt can improve the performance of asphalt pavement; never less it had a cost implication. Therefore, it is essential to waste PP that derived from thermoplastics. The consumption of bitumen as a material of pavement construction will grow as the demand for road infrastructure development increases [12].

Natural rock asphalt is available in abundance in Buton Island, South East Sulawesi, Indonesia. Many researches were conducted to study the existence within the country of large deposits of Buton rock asphalt. In recent years, Butongranural asphalt (BGA) in form of similar grains compose of water content, bitumen content and penetration value those are meet the requirement obtained from rock asphalt by a refinery process. The investigation results have been noticed that Buton natural asphalt can be used as a means of bituminous material of pavement mixture due to its bitumen within rock asphalt has similar properties with the petroleum asphalt (e.g., Gauss (a), Gauss (b), Budiamin, Israil, Bambang) [13-17]. One type of processed Buton asphalt was modified Buton asphalt which is a processed semi-extracted from natural Buton asphalt which can be used as a binder in asphalt mixes [18].

As an upper part of the top layer receives an axial compressive force of vehicle tires hence rupture at the surfacing may be caused by applied compressive stress. To maintain continuity of pavement surfacing without undue crushing compressive strength becomes an essential parameter of ACWC based top layer, as shown in Figure-1. This research use modified Asbuton as binder in order to produce AC-WC mixture. The objective of this paper was to investigate the stress strain relationship of AC-WC mixture with and without PP (1% and 2% asphalt binder by total weight) under short term monotonic compressive load.

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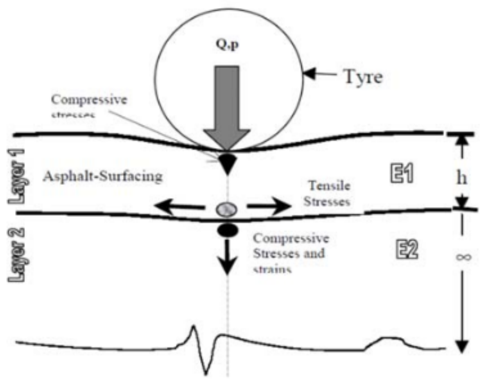

Figure-1. The compressive strength parameter of ACWC based top layer refers to Indonesia's National Highways Authority (NHA)'s Class A.

2. MATERIAL AND METHOD

2.1 Retona Blend 55

Retona blend 55 is a combination of Asbutongrains that have extracted in part with hard asphalt Pen 60 or Pen 80, which is made fabrication by the process as shown in the flowchart in Figure-1, and Table-1 show characteristics of Asbuton modification, Retona Blend 55 used this research.

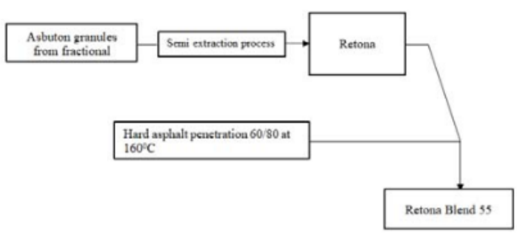

Figure-2. The process of making Retona Blend 55.

Table-1. Characteristics of Retona Blend 55.

No.	Kinds of Testing	Testing Result
1	Penetration before weight loss (mm)	78.6
2	Softening point (°C)	52
3	Ductility in 25°C, 5cm/min (cm)	114
4	Flashpoint (°C)	280
5	Specific gravity	1.12
6	Weight loss	0.5
7	Penetration after weight loss (mm)	86

2.2 Polypropylene (PP)

Polypropylene (PP) is a thermoplastic polymer made by the chemical industry and used in various applications. This material has a high melting point of 190-200^{0}C. Waste PP obtained from disposable cups that collected from domestic waste. Grated plastic waste used (passed filter no.4 and held in filter no.50) obtained from grated PP type plastic bottles with manual grater [19].

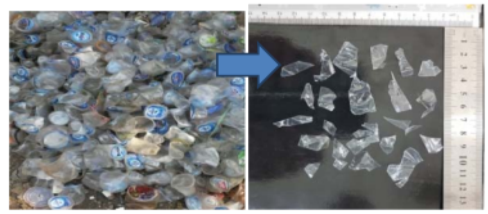

Figure-3. PP plastic waste.

2.3 Aggregates

Aggregate used is 1-2 cm crushed stones and 0.5-1 cm broken stones, and using fine aggregates held by sieve 200 or stone ash passed through sieve 200, which is filler. The aggregate is taken from the BiliBili river Parangloe sub-district, Gowa Regency, South Sulawesi.

Table-2. Properties of coarse aggregate.

Properties	(Crushed Stone)	
	0,5-1 (cm)	1-2 (cm)
Water absorption, %	2.071	2.08
Bulk specific gravity	2.622	2.627
Saturated surface dry specific gravity	2.677	2.682
Apparent specific gravity	2.773	2.779
Flakiness index, %	20.1	9.38
Abrasion aggregate, %	25.72	24.36

Table-3. Properties of fine aggregate.

Water Absorption, %	**2.792**	
Sand Equivalent, %	**89.66**	
Bulk specific gravity 2.449	Saturated surface dry specific gravity 2.518	Apparent specific gravity 2.629

Table-4. Properties of mineral filler.

Water Absorption, %	**2.283**	
Sand Equivalent, %	**69.57**	
Bulk specific gravity 2.595	Saturated surface dry specific gravity 2.654	Apparent specific gravity 2.758

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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2.4 Combined Aggregate Gradation and Mixtures Design

The combined aggregate gradation is shown in Figure-4. All mixtures prepare in the laboratory. The Retona Blend 55 optimum content is 6.25%. Table-5 shows the weighted mixture of the AC-WC mixture. Retona Blend 55 aggregates and fillers are mixed and compacted into cylindrical molds with a capacity of 1,600 grams to get the specimen height of 100 mm and 100 mm diameter. In the laboratory, aggregates and binders (Retona Blend 55) mixed and compacted at 160 ± 0.5°C. The specimens are compressed with 75 blows to each face using Marshall Compactor. After compaction, the specimen removed from the mold and allowed to cool. The mixing and compaction process conducted in laboratory room temperature 27˚C.

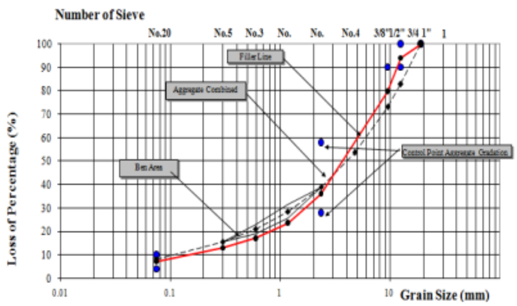

Figure-4. Combined aggregates gradation.

2.5 Compressive Strength

A compressive strength test will show the collapse that occurs after experiencing maximum stress on the test object. Besides, the test specimen will also experience a change in length, which can be known based on the reading deflection value. This test was conducted to determine the material ability in accepting the compressive force, using research standards SNI 03-6758-2002 [20].

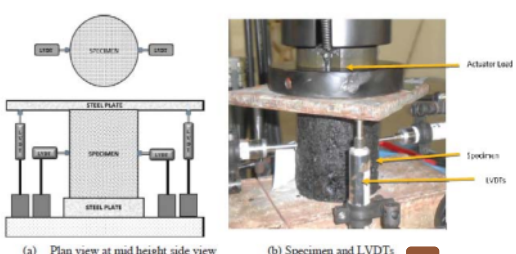

Figure-5. Sketch of compressive strength testing.

3. RESULTS AND DISCUSSIONS

3.1 Stress-Strain Behavior

The relationship of stress-strain AC-WC mixture with PP variation is shown in Figures 5-7. As shown in the figure, the linear stress-strain relationship is 75%, 85% and 80% of the peak stress in each specimen which is without PP and with 1% PP and 2% PP, respectively. Also, it appears that all specimens have elasticity; this indicates that brittle that occurs after being Retona Blend 55 mixed with PP keeps the specimen elastic. After reaching the peak stress, the stress decreases but the strain continues to increase. This shows that the AC-WC mixture, although fragile, is not destroyed suddenly.

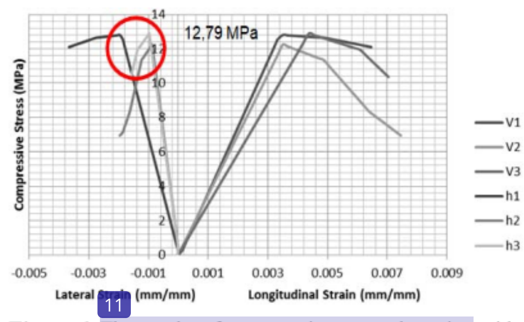

Figure-6. The results of compressive strength testing with 0% content of plastic waste.

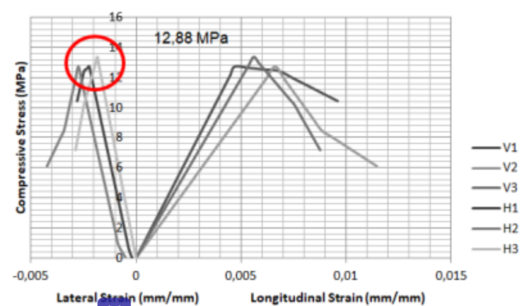

Figure-7. The results of compressive strength testing with 1% content of plastic waste.

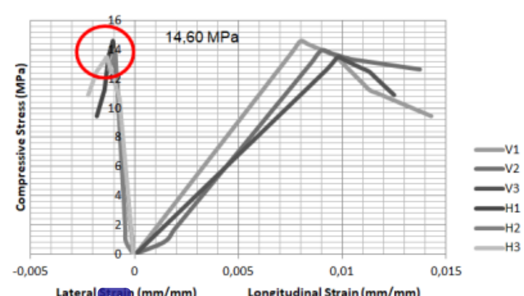

Figure-8. The results of compressive strength testing with 2% content of plastic waste.

3.2 Compressive Strength Value

Based on the compressive strength test results, it appears that an increase in compressive strength values along with the addition of PP plastic waste content. The compressive strength values for various curing variations are presented in Figure-9. The increase occurred from a

VOL. 15, NO. 17, SEPTEMBER 2020 ISSN 1819-6608
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mixture that uses PP plastic waste 1%, and 2% to untreated material is 0.69% and 12.39%, respectively.

Asphalt mixture using PP obtain the stress value is higher than the mixture without PP. This indicates that the asphalt mixture with PP is more resistant to deformation caused by the short term monotonic compressive load. The reason that makes the asphalt mixture AC-WC with PP can withstand higher stress is the filler within PP can fill the voids in asphalt mixtures that contribute to the higher stability.

This result due to excessive MBA, PP and aggregates coagulates together to form weak points inside the mixture and decrease the bond strength between MBA and aggregate-filler. When MBA containing petroleum bitumen, mineral and bitumen Asbuton are blended to produce a mixture, the chemical components of asphalt containing MBA bitumen and aggregate-filler have a rearrangement, and a layer of membrane is formed to cover aggregate. The pores those left by the water of the different asphalt mixture were filled by the presence of finer solid mineral (filler) of MBA. As a result as shown in Figure-6 until Figure-8 AC-WC mixture containing PET and MBA have the sufficient stability with resistance to deformation and the sufficient strength to withstand the compressive load.

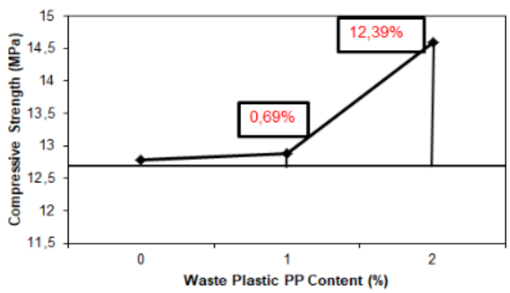

Figure-9. The effect of adding plastic waste to the compressive strength of the asphalt mixture.

4. CONCLUSIONS

Based the compressive strength test results, there appears an increase in the compressive strength value along with the addition of PP plastic waste content where the compressive strength value of untreated plastic waste is 12.79 Mpa, and there is an increase plastic waste level of 2% by 14.60 MPa. This condition shows that PP plastic waste contributed positively to the increase in compressive strength value. Besides, increased compressive strength also can occur due to the modification of Retona Blend 55 type of Asbuton integrated with PP plastic waste.

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PAGE 2

PAGE 3

PAGE 4

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