EFFECT OF PALM OIL FUEL ASH (POFA) ON THE DURABILITY OF ASPHALTIC CONCRETE

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Abstract- The Cantabro durability test is usually used for open graded asphalt mixtures and has seen little use with dense graded mixtures. This paper presents durability data from the Cantabro test for Palm oil fuel ash (POFA) modified dense graded asphaltic concrete AC 14. The nature and amount of filler in an asphaltic concrete mixes significantly affect its design and performance. POFA is an ash obtained from the burning of waste material generated from the production of crude palm oil which is of high quantity in Malaysia. A number of trial mixes were prepared using the Marshall Mix design procedure with 5% POFA and 1% Ordinary Portland Cement (OPC) as filler materials to arrive at asphalt concrete mixtures that fulfil the Marshall criteria. Cantabro durability test was used to measure the durability of the asphaltic concrete. The results show that Marshall stability, flow, stiffness and cantabro loss values shows general improvement for the POFA modified asphalt compared to the control specimens.

Keywords- Palm oil fuel ash (POFA), Filler, Durability, Asphaltic Concrete.

I. INTRODUCTION

Malaysia is witnessing rapid economic development in recent years, and this has placed high performance demand on its highway infrastructure. Evidence of early pavement failures has been widely reported on Malaysian roads due to increase axle loading among other things. This trend has pushed the conventional design methods and construction materials to the edge. Thus the need for sustainable construction materials cannot be overemphasize.

One way to assess durability would be to measure the oxidation behavior of the bitumen alone and try to identify a level of viscosity at which fretting begins. However, this would ignore factors such as void content and inter-connectedness, binder film thickness and aggregate gradation, all of which affect the rate of bitumen oxidation and the ability of the aged mix to withstand traffic stress. Therefore a test to compare the durability of different hot mix asphalt formulations needs ideally to be based around the ageing and the resulting abrasion resistance properties of the compacted mix, rather than predicted solely from the behavior of the oxidized binder.

The Cantabro test is a special for porous asphalt to evaluate the resistance to the particle loss by the abrasion and the effect of impact. This test is a measure for degradation of mineral aggregates of standard grading resulting from a combination of actions including abrasion and impact in a rotating steel drum. As the drum rotates, a shelf plate picks up the sample carrying it around until it is dropped to the opposite side of the drum creating an impact crushing effect. The contents then roll within the drum with an abrading action until the shelf plate picks up the sample and the cycle is repeated. Cantabro loss is used as an important indicator for bonding properties between aggregate and bitumen. The Cantabro test is worth investigating further for dense-graded mixtures.

Fillers have only been thought to fill voids in the aggregate. However, studies indicated that the role of fillers in asphalt mixture performance is more than filling voids depending on the type used. Many studies have been carried out on effects of fillers on the behavior of asphalt mix, and . Different filler materials may have different mechanical properties in the asphalt mixture. However, a thorough understanding of the effect of fine particulate fillers in asphalt binders and mixes has not been reached.

Malaysia is one of the leading producers of crude palm oil with around 41% of the total world supply in years 2009–2010. The by-product of Palm oil production has been disposed as waste thus causing environmental problems and health hazards. Some of the waste materials with high fuel value, such as palm oil husks and shells, can be reused as fuel to produce steam for generating electricity, which is required for extracting crude palm oil. After combustion, about 5% of palm oil fuel ash (POFA) or boiler ash is produced. POFA when properly processed has shown to be a good construction material in cement concrete and mortar.

Reference, reported that the replacement of 5% mineral filler by POFA improved the performance of asphaltic concrete in terms of resilient modulus, stiffness and fatigue properties. In another study, it was found that ACW20 design can apply POFA as filler in particular percentage rate.

This study therefore, evaluated the effect of POFA on the durability of asphaltic concrete using AC 14 asphaltic concrete for wearing course. The

mechanical properties of asphaltic concrete considered were stability, flow, stiffness and cantabrodurability test. Marshall mix design procedure was adopted.

II. MATERIALS

Asphalt cement used in this study was 80/100 penetration grade. Since the performance of filler is of concerned here, commonly use asphalt cement is selected.The aggregate used in this study was granite stone obtained from Malaysia Rock Product Sdn Bhd. (MRP) at UluChoh, Pulai, JohorBahru.The crushed stones (coarse and fine) obtained from the quarry was blended to meet the gradation requirement of AC14 as recommended by the Malaysia Ministry of Public Works (JKR) gradation for a heavy traffic wearing course. Two types of filler materials were used in the study, Palm Oil Fuel Ash (POFA) and Ordinary Portland Cement (OPC). POFA used in this study was sieved through 75µm sieve to ensure that it satisfied ASTM filler material definition of 70%-100% passing 75µm sieve.

III. METHODOLOGY

(A) Sample Preparation
To achieve the objectives of this study, 18 samples were preparedusing 5% POFA as an additive of the mineral filler and 1% OPC. 15 samples were used to establishthe optimum binder content (OBC) through the Marshal procedure with 4-6% bitumen contentrange. Once the OBC for the POFA modified asphalt was obtained, three (3) samples were preparedat OBC and each sample was tested for cantabrodurability. Another 18 samples were prepared as control using 5% mineral (conventional) filler and 1% OPC.15 samples were used to establish the OBC of the control sample (samples with no POFA), and 3samples for cantabrotest which serve as bases for comparison. All samples werepreprepared by dry mix.

(B) Preliminary tests.
All laboratory tests were conducted in accordance with ASTM specifications. Preliminary tests carried out include specific gravity of aggregate, whichprovides important information for designing HMA because it is used to calculate VTM and VFB. ASTM C127-12 standard for determination of specific gravity of coarse aggregate was adopted in this study. Similarly, ASTM C 128-12, was adopted for determining the specific gravity of the fine aggregate. The effective specific gravity cannot be measured directly, so it was calculated from the theoretical maximum density. The theoretical maximum density was determined in accordance with ASTM D2041/D2041M – 11. The specific gravity and penetration grade of binder was adopted based on the suppliers' measurements, likewise for POFA and OPC. Sieve analysis was carried out according to ASTM C136 – 06, for the selection of AC14 aggregates based on JKR 2008 recommendation.

(C) Marshall Mix Design
Marshall Stability and Flow tests were carried out in order to find the optimum asphalt content (OAC) of the mixes. The Marshall Mix design procedure currently used in Malaysia for asphalt concrete mix design to determine the optimum asphalt content was adopted.

(D) CantabroDurability Test
This test procedure measures the breakdown of compacted specimens utilizing the LosAngeles Abrasion machine. The percent of weight loss (Cantabro loss) is an indication ofdurability and relates to the quantity and quality of the asphalt binder. Thepercentage of weight loss is measured and reported. In the test, the specimen is put into a Los Angeles drum without steel balls, and then given 300 rotations with a speed of 30 to 33 rotations per minute. The specimens are weighed before and after the rotations and the weight loss or Cantabro loss value is calculated. Cantabro Loss was calculated using Eq. 1;

$$CL = \frac{A-B}{A} * 100 \qquad (1)$$

Where:
CL = Cantabro Loss, %
A = Initial weight of test specimen
B = Final weight of test specimen.

IV. RESULTS AND DISCUSSION

(A) Preliminary Test Results
The results of specific gravity test conducted on both coarse and fine aggregatesware presented in table 1.

Table 1 Physical Properties of Aggregates

S/N	PROPERTY	VALUE (g/cm^3)
1.	Bulk Specific Gravity of Aggregate	2.60
2.	Effective Specific Gravity of Aggregate	2.64
3.	Specific Gravity of Bitumen	1.03
4.	Specific Gravity of POFA	2.22

(B) Optimum Asphalt Content
A 4-6% asphalt content range was used to determine the optimum asphalt content for the mixes considered in this study. Parameters used in arriving at the OAC are Stability, Flow, VTM and VFB in accordance with JKR 2008 AC 14 for wearing coarse recommendations. Table 2 presents the OAC obtained.

Table 2.OAC for each mix

S/N	TYPE OF MIX	OAC (%)
1.	No POFA (Control)	5.2
2.	5% POFA	6.0

It was observed that based on the OAC; there is probably no significant difference between5% modified asphalt and the control.

(C) Marshall Characteristics

Marshall Characteristics; stability, flow, stiffness, VTM and VFB were measured at OAC for all the mixes and compared with JKR recommendation for AC 14 as presented in table 3.

Table 3 Marshall Mix Design Characteristics at OAC

MASHALL PARAMETERS	TYPE OF MIX		JKR 2008
	No POFA (Control)	5% POFA	
Stability (N)	16088	20924	>8000
Flow (mm)	3.55	3.70	2.0-4.0
Stiffness (N/mm)	4120	5670	>2000
VTM (%)	4.8	4.6	3.0-5.0
VFB (%)	71	70	70-80

It was observed that both mixes passes the JKR recommendation for stability, flow, stiffness, VTM and VFB.

(D) CantabroDurability Test

The result of CantabroDurability Test conducted on 6 samples, three samples representing each mix is summarized in table 4.

Table 5CantabroDurability Results

S/N	TYPE OF MIX	CANTABRO LOSS (%)
1.	No POFA (Control)	2.50
2.	5% POFA	1.15

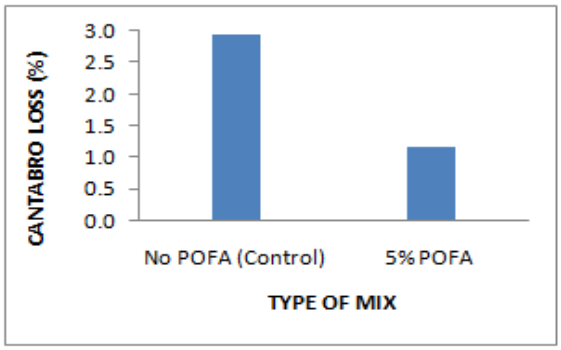


Fig. 1 Comparison of Cantabro Durability Results

The result of Cantabrodurability test shows some variation with POFA, and from figure 1, it can be observed that the sample with 5% POFA have better durability compared to the controlsample. It is expected that with increasing binder content

CONCLUSION

Conclusively, the cantabro loss results shows more than 50% improvement in the durability of POFA modified asphalt. Marshall stability, flow and stiffness values were generally better for POFA modified asphalt than the control.

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