UNIVERSITI TEKNOLOGI MARA

CONFERENCE PROCEEDING

ICITSBE 2012

1ST INTERNATIONAL CONFERENCE ON INNOVATION AND TECHNOLOGY FOR SUSTAINABLE BUILT ENVIRONMENT

16 -17 April 2012

Organized by:
Office of Research and Industrial
Community And Alumni Networking
Universiti Teknologi MARA (Perak) Malaysia
www.perak.uitm.edu.my

PAPER CODE: CT 08

INVESTIGATION ON USING OIL PALM FIBER IN POROUS ASPHALT

Tamalkhani Syammaun [a] and Mohamed Rehan Karim [b]
Civil Engineering Department, University of Malaya, 50603, Malaysia
[a]tamal_s27@yahoo.com , [b]rehan@um.edu.my

Abstract
This paper presents the results of a preliminary investigation on using oil palm fiber (OPF) in porous asphalt (PA). The samples were prepared with various percentages of OPF (0%, 1%, 2%, 3%, 4% and 5%) by evaluating the weight of bitumen. The laboratory tests included permeability, air abrasion loss and water abrasion loss. The results indicate that the addition of OPF provide a positive effect on the properties of PA. Certain amount of oil palm fiber as an additiveappears to improve resistance to ravelling and stripping. However, adding too much OPF would result in higher abrasion loss value and increase the air voids.

Keywords: Porous Asphalt, Oil Palm Fiber, Permeability, Abrasion Loss.

1. Introduction

Porous Asphalt (PA) is widely used for water drainage and noise reduction in order to improve traffic safety and comfort for both drivers and the residents living in the vicinity of roads (Takahashi *et al*., 2003). It was developed in the early 50s in Europe and the United States. Porous asphalt is composed predominantly of narrowly graded crushed coarse aggregate without significant fines, which results in increased surface friction and permeability and noise reduction (Hossam *et al.,* 2005). This kind of asphalt has also been called drainage asphalt, whispering asphalt, popcorn asphalt, open friction course and porous friction course. There are several advantages and also limitations of porous asphalt based on works from previous researchers. In general, the advantages may be identified as follows:

1. Reduce splash and spray effect
2. Reduce aquaplaning effect
3. Reduce glare effect
4. Improved road safety
5. Noise reduction

The limitations of porous asphalt include the following:

1. Air void can quickly be filled with detritus. Pressure washing does not clear the voids and the only alternative is to remove the contaminated surface and relay new material.
2. The unit cost of porous asphalt is far higher than conventional dense wearing course.
3. The predicted lifetime for porous asphalt is about 8 years against 20 years for conventional method.

Pavement is an element of road infrastructure that plays an important role in supporting the riding quality, comfort and safety of the road user. Unfortunately, various pavement distresses can be found in asphalt pavement which affects its performance and serviceability. Improvements on the asphalt pavement can usually be made by improving the properties of the binder and/or improving the properties and gradation of the aggregates as well as improving the properties of the mix.

Various kinds of fibers have been utilized as fillers in asphalt mixes for the purpose of improving certain properties of the mix. There are several types of fibers that could be use in asphalt mixture, such as polyester fiber, cellulous fiber, glass fiber and mineral fiber (Mahrez, *et al*., 2010). This exploratory study aims to use oil palm fiber (OPF) in its natural form in bituminous mixes primarily to help increase binder film thickness around aggregates without excessive binder drainage. As oil palm fiber may be considered as waste material its successful utilization in pavement mixes help address the issue of waste management and environmental conservation. Since OPF is abundant in Malaysia it would be a possibility to conduct an exploratory laboratory study to investigate the use of this fiber in PA mixtures according to Malaysia's condition. In this study, the samples were prepared and tested to evaluate falling head permeability, cantabro on air cured sample, and cantabro on water cured sample of porous asphalt.

2. Methodology

2.1 Materials

In this study, aggregates employed were from locally crushed granite aggregates. The aggregates were selected based on the selected gradations which have been obtained from Malaysian Public Works Department porous asphalt (PA-Grading B) as shown in Table 1. The conventional bitumen penetration-grade 80/100 was used and hydrated lime was added as filler. Meanwhile, oil palm fiber (OPF) used was obtained from the Malaysian Palm Oil Board (MPOB).

Table 1: Gradation of Porous Asphalt (Grading –B)

Sieve Size (mm)	Specification Passing range (%)	Used Passing (%)
20.0	100	100
14.0	85-100	92.5
10.0	55-75	65
5.0	10-25	17.5
2.36	5-10	7.5
0.075	2-4	3

2.2 Experiment

The amount of binder contents used in the mixes are 4%, 4.5%, 5%, 5.5%, and 6% by weight of aggregates. Various percentages of OPF (1%, 2%, 3%, 4% and 5%) were used and compared with control sample (no fibers). The OPF was clean for other materials and sieved through a 500 µm sieve. The samples were prepared using Marshall Compactor by applying 50 blows per-face, and tested for permeability, raveling, and water damage.

2.2.1 Permeability Test

Falling Head Permeability test was used in this study to evaluate the effect of OPF content on drainage capability of the porous mix. Guwe *et al.* (2000) mentioned that the measurement of permeability or drainage capacity will more accurately quantify the performance of porous asphalt than the air voids content. If the air voids are not interconnected the voids will not contribute to the drainage capacity of the porous mix. The coefficient of permeability can be calculated as follows (1).

$$k = 2.3\ aL \log10\ (h1/h2)\ /\ At \qquad (1)$$

Where: k = coefficient of permeability (cm/s)
a = Area of stand pipe (cm2)
t = time interval (s)
A = cross sectional area sample (cm2)
L = length of sample (cm)
h1 = initial head (cm)
h2 = final head (cm)

2.2.2 Cantabro Test on Air Cured Samples

The Cantabro test is a special test for porous asphalt to evaluate the resistance to particle loss by abrasion and impact. The Cantabro loss is used as an important indicator for bonding properties between aggregate and bitumen (Chui-Te, 2008). In this study, the samples were tested at temperature of 25°C and the weight of the Marshall sample was recorded before placing it in a Los Angeles drum (ASTM C131) without the steel balls. The drum goes through 300 rotations with the speed of 30 to 33 rpm and then the weight loss was calculated as illustrated in equation (2).

$$\text{Weight Loss (\%)} = [\,(Mi - Mr\,) / Mi\,] * 100 \quad (2)$$

Where; *Mi and Mr* are respectively the initial mass of sample and mass of sample after rotation.

2.2.3 Cantabro Test on Water Cured Samples

The Cantabro test on water cured samples was used to measure the resistance of mixes to stripping and water damage. In this study, the initial weight of the Marshall sample was recorded and then samples were placed in a water bath for four days at 49±1°C. The samples were taken out of the bath on the fifth days and leave for 18 hours. The Cantabro test was then conducted according to the same procedure as explained earlier.

3. Results and Analysis

3.1 Permeability

Figure 2 illustrates the results of permeability on porous asphalt for various binder contents using falling head permeameter. The results clearly show that the coefficient of permeability decrease as the binder content increase. As a result with no fiber (0% OPF) at 4%, 4.5%, 5%, 5.5% and 6% record a coefficient of permeability of 0.200, 0.182, 0.171, 0.164, 0.140 cm sec^{-1}, respectively. Besides that, results also showed that the permeability coefficient at 6% binder content is the lowest. It can be inferred that the amount of binder content is clogging the air voids, hence slowing the flow of water through the samples.

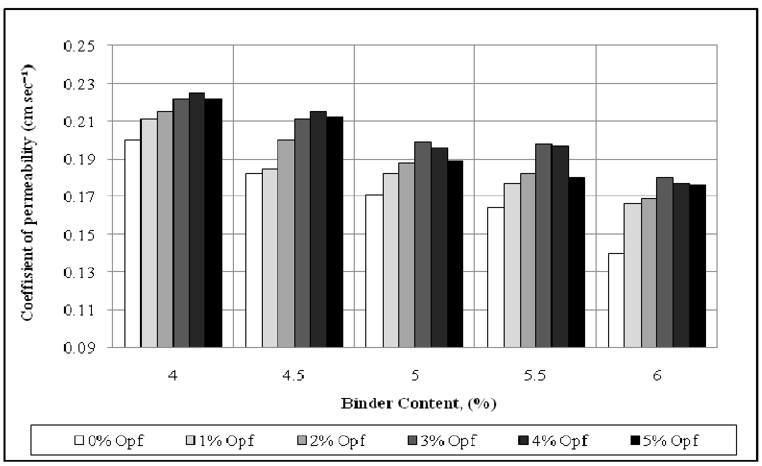

Figure 2: Permeability coefficient results versus binder content

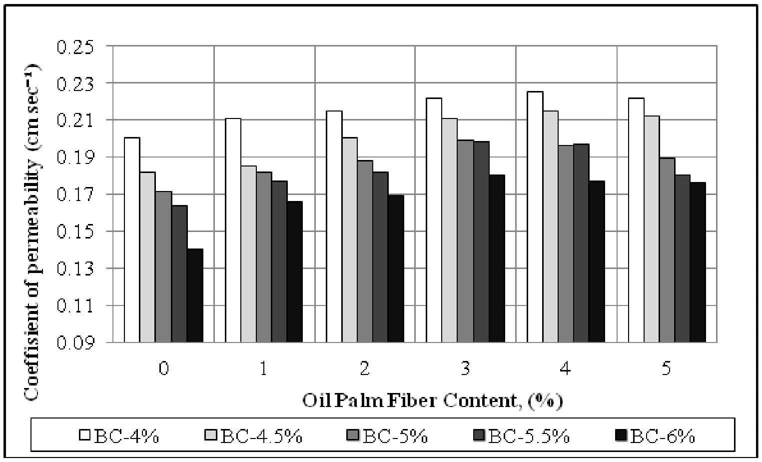

Figure 3: Permeability coefficient results versus OPF content

Figure 3 shows the permeability coefficient in the mixes with various fiber percentages. The results indicated that for any particular OPF content the coefficient of permeability will decrease as the binder content increases. The mix with 0% (no fiber) and 1% OPF shows the lowest permeability coefficient. It seems that OPF may increase the air voids in the mix for the certain amount.

Two-factor analysis of variance (ANOVA) was used to evaluate the results of permeability test with various binder content and OPF content at 95% confidence level ($\alpha = 0.05$). As such, the addition of OPF significantly different on permeability coefficient value which F value of 97.0058 (F=97.0058>F-critical=2.86) and P-value smaller than 0.05 (Table 2).

Table 2: Two-factor ANOVA on the permeability coefficient

Source of Variation	SS	df	MS	F	P-value	F crit
Binder content	0.00791	4	0.00197	97.0058	8.414E-13	2.86
OPF content	0.00347	5	0.00069	34.1085	3.961E-09	2.71
Error	0.00040	20	0.00002			
Total	0.01179	29				

3.2 Air Abrasion Loss (Air Cured Samples)

The effects of various percentages of binder on air cured samples are summarized in Figure 4. The maximum permissible abrasion loss should be not more than 18% (JKR, 2008). The results show that the abrasion loss decreases with increase binder content. Moreover, sample made by 5%, 5.5% and 6% binder content shows the best resistance to abrasion in porous asphalt. It clearly shows that the increasing amount of binder is sufficient to coat aggregates and fibers.

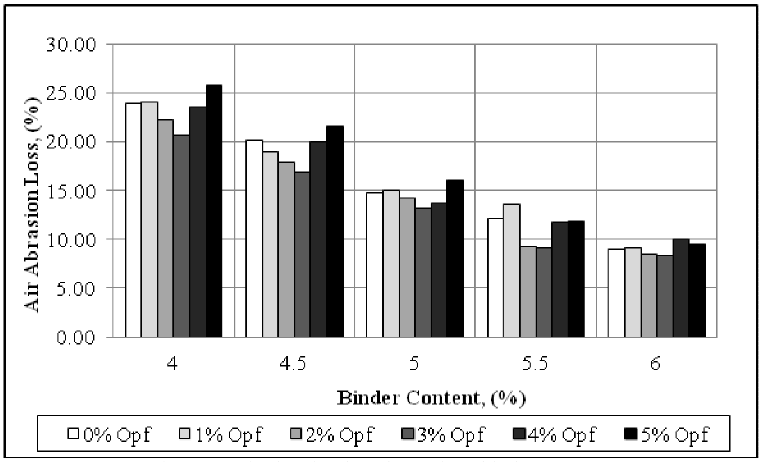

Figure 4: Air abrasion loss for various binder contents

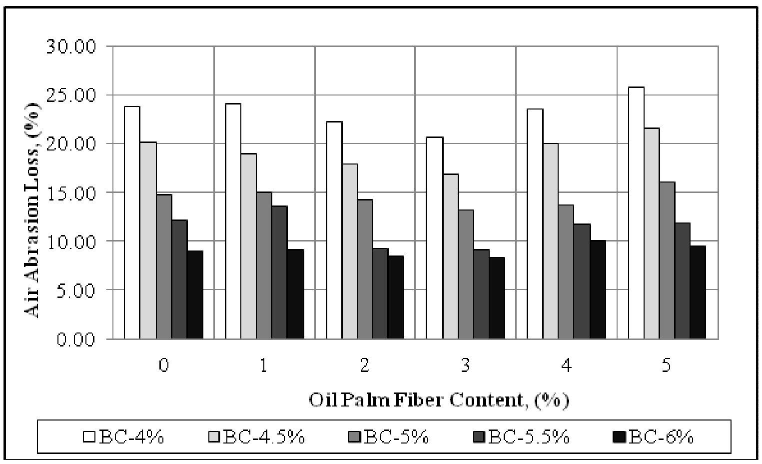

Figure 5: Air abrasion loss for various OPF contents

Figure 5 shows that at any particular OPF content, the air abrasion loss will decrease as the binder content is increased. As such, the use of OPF in porous asphalt requires a bit more binder in order to avoid abrasion loss.

From two-factor analysis, it is found that the OPF influence the performance of air abrasion loss. F value for various OPF contents is 290.83 which is higher than F-critical of 2.86 and its P-value is 2.06E-17 which is smaller than 0.05. A summary of analysis of variance results are given in Table 3.

Table 3: Two-factor ANOVA on air abrasion loss

Source of Variation	SS	df	MS	F	P-value	F crit
Binder content	811.10	4	202.77	290.83	2.06E-17	2.86
OPF content	38.03	5	7.60	10.90	3.60E-05	2.71
Error	13.94	20	0.69			
Total	863.08	29				

3.3 Water Abrasion Loss (Water Cured Samples)

Figure 6 illustrates the water abrasion loss with various binder contents. The maximum permissible abrasion loss should be not more than 40% (Skvarka, 1996). As a result, the abrasion value shows the same behavior as the cantabro test on air cured sample whereby the abrasion loss decreases as the binder content increases. The results also revealed that generally only samples prepared with 5%, 5.5% and 6% binder content satisfies the recommended limit value.

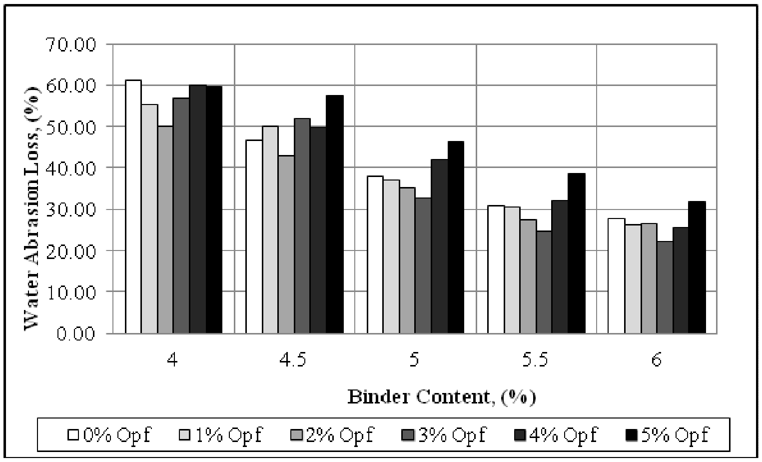

Figure 6: Water abrasion loss for various binder contents

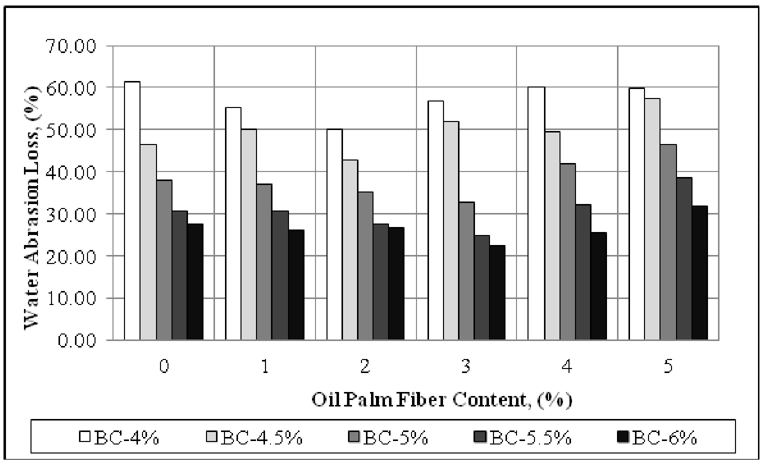

Figure 7: Water abrasion loss for various OPF contents

Base on Figure 7, the sample made by 3% OPF content has better resistance to water abrasion loss for all mixes, except for samples made by 4% and 4.5% binder content, with values of 56.86%, 52.01%, 32.70%, 24.82%, and 22.31% for binder content 4%, 4.5%, 5%, 5.5%, and 6% respectively. The percentage weight loss for water cured samples is greater than that of air cured samples. This indicated that water did influence the abrasion resistance and also the binder-aggregate bonding in the porous asphalt.

Table 3 shows the ANOVA results on water abrasion. The results indicated that OPF content gave significant effect on porous asphalt with F value of 125.99 (F=125.997>F-critical=2.866) and P-value smaller than 0.05.

Table 4: Two-factor ANOVA on water abrasion loss

Source of Variation	SS	df	MS	F	P-value	F crit
Binder content	3932.00	4	983.00	125.99	6.967E-14	2.86
OPF content	333.54	5	66.70	8.55	0.00	2.71
Error	156.03	20	7.80			
Total	4421.58	29				

4. Conclusion

From the exploratory laboratory investigations the use of OPF affects certain properties of the porous asphalt mix. For any particular binder content, the permeability of the porous mix improves as the amount of OPF is increased. As the amount of OPF to be used increases, more binder is needed to avoid excessive abrasion loss. However, as the amount of binder to be used increases, the permeability of the porous asphalt decreases because the binder began to clog the air voids. As such, there is a need to strike a balance between the two opposing requirements if OPF is to be used as an additive in porous asphalt. Nevertheless, this initial study would hopefully open the door to more in-depth study on this matter.

References

Chui-Te, C. (2008). *Use of ground tire rubber in asphalt pavements: Field trial and evaluation in Taiwan*. Resources, Conservation and Recycling, 52(3), 522-532.

Guwe, Y.K., Chuai, C.T., Fwa, T.F., and Tan S.A. (2000). *Developing permeability meaning procedure for drainage mix on expressway*. Proceeding of SPT2000, 4th PES-CTR Symposium of Pavement Technology: Singapore.

Hossam F.H. and Khalifa S.A. (2005). *Effect of organic fibers on open-graded friction course mixture pro*perties, International Journal of Pavement Engineering, 6:1, 67-75

Isabelle G.R. Skvarka (1996). *A Rational for the design of open graded friction course asphalt*, M.Sc. Thesis, Royal Melbourne Institute of Technology.

JKR (2008). *Standar specification for road work. Section 4. Flexible Pavement*. Public Work Department. Ministry of work Malaysia. Kuala Lumpur.

Mahrez, A. and Karim, M.R. (2010). *Fatigue characteristics of stone mastic asphalt mix reinforced with fiber glass*. Int. J. of the Physical Sciences, Vol.5(12):1840-1847.

Takahashi S., Poulikakus L.D., and Partl M.N. (2003). *Evaluation of improved porous asphalt by various test methods*, Proc. 6th International RILEM symposium, Performance Testing and Evaluation of Bituminous Material, Zurich, pp 230 – 236