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## Performance of macro clay on the porous asphalt mixture properties

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**Abstract.** Porous asphalt pavement already well known as one type of pavement since many decades, however due to lack in strength it is not been widely used in road construction especially in high stresses areas. Many research had been conducted by researchers in order to improve the durability and increase the service life of the road. One of the methods that commonly used is through asphalt modification. Objectives of this study are to discuss influence of macro-clay in terms of physical and rheological properties and their effect on performance of porous asphalt mixture. Various percentage of macro-clay (starting from 2% to 8%) was blended in an asphalt binder and compacted using the Marshall compactor. The blended asphalt was characterized using penetration, softening point test and penetration index compared with unmodified binder. Performance tests of asphalt mixture were carried out such as Los Angeles Abrasion Value (LA AV) and Stability and Flow test in order to determine the strength and durability. The results show that the addition of macro-clay would increase in softening point but decrease in binder penetration. Based on the results, while macro-clay changes physical and rheological properties of bitumen and increase stiffness, it also improves strength and durability resistance, as well. Generally, the best improvements in the modified binders were obtained with 4% of macro-clay.

### 1. Introduction

Due to tropical climate in Malaysia where we receive excessive rainfall especially during monsoon season, proper management of surface water is a priority. This precipitation can prove severely harmful in areas with a limited or insufficient storm drain infrastructure in place. When water cannot penetrate into the ground, which resulting water splashing during vehicle run-off and may lead to hydroplaning. Hydroplaning occurs when a tire encounters more water than it can scatter which result in loss of steering, braking and power control. Due to this issues porous asphalt pavement will be consider as most suitable types of pavement that should be used in road construction. However, the main weakness found in porous asphalt binder are aging and stripping [1]. Porous asphalt has a possibility being water sensitive. Since rain water can infiltrate through the porous layer, it has chances to remain inside for long time. This will cause stripping of binder film from the aggregate to take place [2]. So the ideal asphalt should possess both: (1) high relative stiffness at high service temperatures (summer) to reduce rutting and shoving and; (2) increased adhesion between the asphalt and aggregate



in the presence of moisture to reduce stripping. In order to overcome this issue, modified binder has been introducing. There are many types of modifier that widely used in construction and one of them is clay. This study was focus on effect of Kaolin (macro- clay) on performance of porous asphalt mixture. Kaolin is mineral clay and normally found in white colour. Accordingly, an early assumption states that porous asphalt with modified asphalt possesses enhanced engineering properties. Researchers [3,4] suggested that clay modifications improve some characteristics of asphalt binders and asphalt mixtures, but more research is required before it can be applied on the large scale [5].

## **2. Materials and methods**

### *2.1. Binder and aggregate*

This study used conventional bitumen with penetration grade (PEN) 80/100 supplied by Shell Malaysia. Kaolin as polymer modified and the granite aggregates supplied by the Ulu Choh quarry were used throughout the experiment. The basic bitumen tests for example penetration and softening point test were conducted to determine the bitumen properties.

### *2.2. Penetration test*

The consistency of the bitumen was measured by the penetration test according to the standard ASTM D5/D5M-13 [6], which is the simplest test to obtain the penetration value of the bitumen. A low penetration value indicates the hardness of the bitumen. The bitumen was heated and poured into a penetration cup prior to testing. The sample was then placed into a water bath for 1 h at 25°C after it was cooled. The penetration equipment was used to perform the test with the applied total load of 100g for 5 s at 25°C.

### *2.3. Softening point test*

Bitumen requires to definite temperature to soften. Therefore, determining the softening point of bitumen is important for result comparison. The softening point test was conducted according to ASTM D36/D36M-14e1 [7]. The bitumen was heated and poured into two rings and cooled for 30 min. The two rings and two balls were placed on each sample and heated. The temperature of the two samples was calculated.

### *2.4. Performance of porous asphalt*

The stability and flow value of porous asphalt samples were determined using the Marshall testing apparatus at a sample temperature of 60°C. Durability test was conducted to evaluate the performance of porous asphalt. Porous asphalt durability was evaluated in terms of resistance against abrasion loss. The compacted porous asphalt samples in this test were subjected to 300 rotations in the Los Angeles Abrasion Machine. The mass loss percent was used to determine the abrasion resistance of the porous asphalt samples.

## **3. Results and discussion**

### *3.1. Effect of macro-clay on bitumen properties*

The effect of macro-clay as modified bitumen on penetration, softening point and penetration index value are given in table 1. The result shows that the penetration value was constantly decreased as the percentage of macro-clay increased. The results proved that macro-clay had chemically reduced the binder viscosity and increased the binder stiffness which result the decrease in the penetration value and would be useful to obtain stiffer asphaltic concrete [8]. The softening point of samples was meet ASTM D5/D5M-13 [6] specification which requires the softening point between 45°C to 52°C for bitumen PEN 80/100. According to table 1, when macro-clay content increases, the softening point value also increase. These were due to macro-clay reducing the binder viscosity and increasing the elasticity of the asphalt binder to resist deformation, thus resulting in the increased of softening point

value. El-Shafie et al. [3] reported that modified asphalt were less sensitive to high temperature changes and may also be more resistant to plastic deformation (rutting) compared to unmodified asphalt. The Penetration Index (PI) is a measure bitumen susceptible to temperature and is calculated using equation (1) [9].

$$PI = \frac{1952 - 500 \log_{10} pen - 20SP}{50 \log_{10} pen - SP - 120} \quad (1)$$

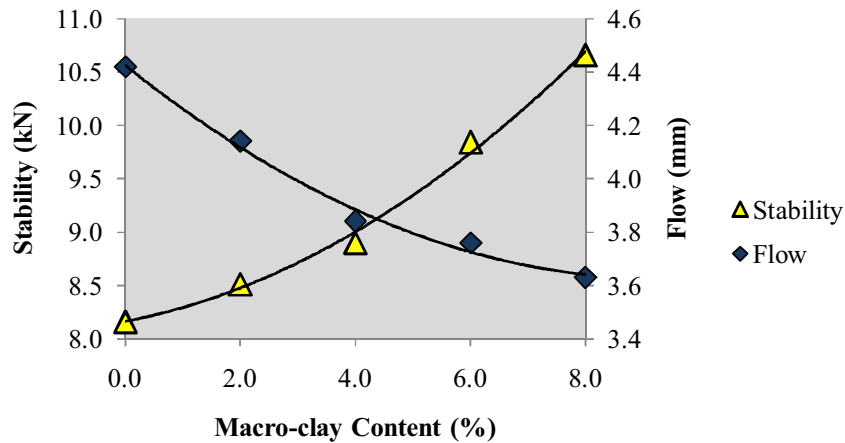
Where pen is penetration (25°C) and SP is softening point. Table 1 shows the effects of macro-clay on PI of asphalt binder. The results indicated that penetration index had increased as percentage of macro-clay increased thus physically macro-clay modified binder become more harden. In addition the increase in PI value also reveals that macro-clay reduced the temperature susceptibility of the bitumen [10].

**Table 1.** Effect of macro-clay on bitumen properties.

Kaolin Content (%)	Penetration (PEN)	Softening Point (°C)	Penetration Index (PI)
0.0	89	46	-0.84
2.0	70	52	-0.59
4.0	60	56	0.66
6.0	54	58	0.81
8.0	45	62	1.15

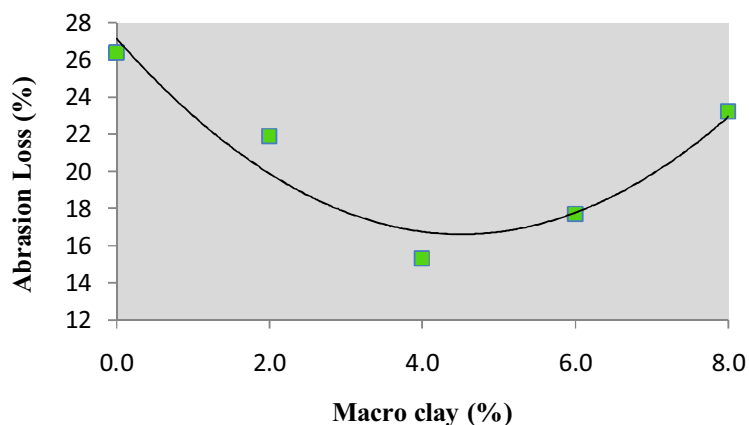
### 3.2. Effect of macro-clay on performance of porous asphalt mixture

*3.2.1. Stability and flow.* From figure 1, the highest stability value occurred at the higher macro-clay content. The sample with a high content of macro-clay seems to improve the performance against permanent deformation. The result also show that the significant increasing in the stability value of the porous asphalt sample when the macro-clay content increase. The values were less varied in terms of flow. However, a slight reduction in the porous asphalt flow occurred when the macro-clay content increase. Previously, Zubeck et al. [11] found that polymer modified asphalt showed good workability and economically feasible while can meet other criteria which can improved the strength of asphalt mixture. The porous asphalt resistance against permanent deformation greatly depend on the binder, which provided stiffer and stronger mixture.



**Figure 1.** Relationship between stability and flow.

**3.2.2. Abrasion loss.** The relationship between the percent of abrasion loss and macro-clay content is illustrated in figure 2. The highest percentage of abrasion loss occurs at 8% of macro-clay. Vanessa and Jorge [12] found that porous asphalt mixtures require a modified asphalt binder in order to give greater cohesion bonding between aggregate and binder. However, high amount of bitumen will be reduce due to high macro-clay content which can cause coating work became harder and at the same times reduce the cohesion. The amount of abrasion loss increase significantly with the increases of macro-clay except for 4%. In term of cost view and ability to reduce the abrasion loss, this is possibly an indication that 4% of macro-clay is the optimum rate of macro-clay as poly modified asphalt.



**Figure 2.** Relationship between abrasion loss and macro-clay content.

#### 4. Conclusions

Based on the analysis and laboratory data, it is found that the addition of macro-clay has hardened the bitumen and reduces its temperature susceptibility as measured by the results from penetration and softening point tests. When penetration increase bitumen become stiff which is good to improve rutting however at the same time bitumen also become brittle which may increase cracking problem. This is also supported by the results obtained from the stability test where the additions of macro-clay increase the asphalt mixture stability compare to the control sample. However, the increase in the bitumen stiffness has reduced its ability to coat the aggregate particles and the bonding strength

as shown in abrasion loss. In order to overcome this issue appropriate amount of macro-clay that use as modifier is a main concern. The amount of macro-clay used should give optimum beneficial to improve the strength and durability of porous asphalt pavement but at the same time can maintain the main purpose of porous asphalt pavement as surface storm management. According to this study, 4% macro clay give the best improvement.

## 5. References

- [1] Tarmuzi N A, Jaya R P, Yaacob H, Hassan N A and Aziz M M A 2015 Aggregate angularity effect on porous asphalt engineering properties and performance, *J. Teknologi* **73** 99-104
- [2] Poulikakos L D, Pittet M, Arnaud L, Junod A, Gubler R, Simond E, Partl M and Dumont A G 2006 *Mechanical Properties of Porous Asphalt, Recommendations for Standardization* (Switzerland: Swiss Federal Laboratory for Materials Testing and Research, Empa) pp 70-76
- [3] El-Shafie M, Ibrahim I M and Abd El Rahman A M M 2012 The additions effects of macro and nano clay on the performance of asphalt binder, *Egyptian J. of Petroleum* **21** 149-154
- [4] Wan Azhar W N A, Bujang M, Jaya R P, Hainin M R, Aziz M M A and Ngadi N 2015 Application of nanotechnology in asphalt binder: a conspectus and overview, *J. Teknologi* **76** 85-89
- [5] Jaya R P, Yusak M I M, Hainin M R, Warid M N M and Wan Ibrahim M H 2014 Porous concrete pavement containing nano-silica: Pre-review, *J. Adv. Mater. Res.* **911** 454-458
- [6] American Society for Testing Materials ASTM D5/D5M-13 2013 *Standard Test Method for Penetration Of Bituminous Materials* (United States: ASTM Standard) pp 1-4
- [7] American Society for Testing Materials ASTM D36/D36M-14e1. 2014 *Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)* (United States: ASTM Standard) pp 1-4
- [8] Hainin M R, Jaya R P, Akbar N A A, Jayanti D S and Yusoff N I M 2014 Influence of palm oil fuel ash as a modifier on bitumen to improve aging resistance, *J. of Engineering Research* **2** 34-46
- [9] Read J and Whiteoak 2003 *The Shell Bitumen Handbook* (Doncaster: Thomas Telford Publishing) pp 29-41
- [10] Che'Mat N, Jaya R P, Hassan N A, Nor H M, Aziz M M A and Che Wan C M 2014 Properties of asphaltic concrete containing sasobit<sup>®</sup>, *J. Teknologi* **71** 27-31
- [11] Zubeck H K, Lutfi R, Stephan S, George M and John Ryer P E 2003 Workability and performance of polymer-modified asphalt aggregate mixtures in cold regions, *Int. J. Pave* **4** 25-36
- [12] Vanessa S A and Jorge E C M 2014 Resistance to degradation or cohesion loss in cantabro test on specimens of porous asphalt friction courses *Procedia – Social and Behavioral Sciences* vol 162 (United Kingdom: Elsevier) pp 290-299

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