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Utilising Malaysian Fibre in Stone Mastic Asphalt as a Replacement of Imported Fibre

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ABSTRACT

Stone Mastic Asphalt (SMA) technology is currently used in many countries. This is a gap grade mix with a high percentage of coarse aggregates. As such there is a tendency for the binder in the gap-graded mix to drain down during the hot weather that may cause premature failure of the mix. Various fibre types have been used successfully in SMA. However, the overall cost of the mix tends to be much higher than that in conventional mix. This paper looks into the suitability of the Malaysian fibre for the use in SMA.

The fibre is analysed and compared with traditional European fibre that is commonly used in SMA. Several experiments on the fibre have been done including Fibre Drain Down Test and Morphological analysis using the Scanning Electron Microscope (SEM). Besides this, chemical analysis was also carried out with a variation of cellulose content, particle size and Gas Chromatograph analysis. The result of the preliminary analysis shows that Malaysian fibre has the potential to replace the imported traditional fibre.

Keywords: Stone mastic asphalt, imported fibre and Malaysian fibre

INTRODUCTION

In this current economic situation, the limited resource that is available should be used at an optimum level to reduce the expenditure of the government in the laying of roads. Roads are the lifelines of a country. The sustainability, of this country's economy depends much on the land transportation system. According to roads branch (JKR 1987) for the past ten years, an estimated RM3581 million has been spent to build roads, of which RM1560 million is spent on the maintenance of the existing roads, due to the fatigue cracking, rutting and stripping problem.

The above figure indicates that maintenance cost for road is very high. To cut down maintenance cost and probably the overall cost of road laying and maintenance, an alternative approach using the most advanced and durable pavement material such as Stone Mastic Asphalt (SMA) has to be conducted.

Objective of Project Study

The main objective of this study is to analyse the suitability of the Malaysian fibre used in Stone Mastic Asphalt. Several experiment or fibre analysis was conducted to determine the characteristic of Malaysian fibre and its usage in SMA. This fibre study includes production, screening, pulping, chemical and mechanical analysis.

BACKGROUND ON STONE MASTIC ASPHALT

Stone Mastic Asphalt (SMA) is a gap-graded mix with a high coarse aggregate content of 70-80%, binder content of 6.5-7.0% and filler contents of around 7-9%. The percentage of fibre that is required for SMA 0.3% and air voids of around 4%.

The skeletal formation of the coarse aggregate provides high resistance to deformation. Adding the fibres to the binder will prevent the asphalt from draining off during storage, transport and laying. Very soft binder may drain down easily. Bethune(1993) states that mastic fills the voids and retaining chips in position. It has an additional stabilising effect, as well as providing the design air voids. The result is a highly durable rut resistant asphalt mix.

SMA can be used on all types of road and it is ideal for roads with heavy traffic. Its high binder content gives a longer life than conventional mixes. The second advantage is its coarse and open texture which generally provides high skid resistance at all speeds, as well as good drainage and fewer spray problems (Bethune 1993).

Analysis of Fibre Morphology by Scanning Electron Microscope

The Scanning Electron Microscope (SEM) output is shown in Plates1,2,3 and 4. Plate 2 shows a thick presence of Malaysian fibre whilst Plate 1 shows otherwise. Plates 3 and 4 shows the state of cellulose fibre after recovering from slight damage after mixing.

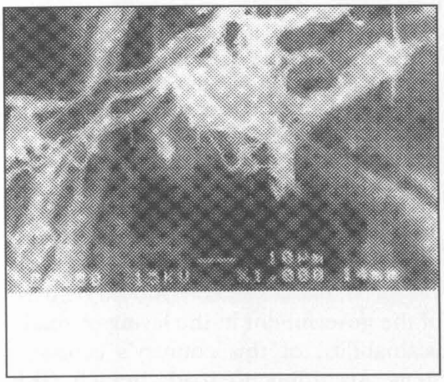

Plate 1: Imported fibre (1000X Magnification)

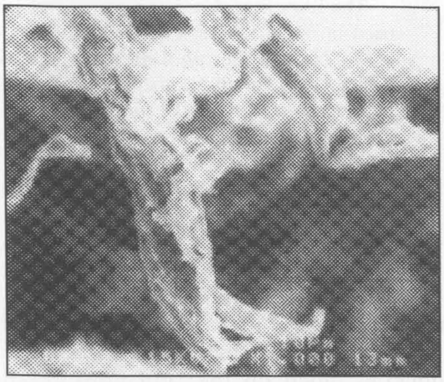

Plate 2: Malaysian fibre (1000X Magnification)

Plate 3: Recovered imported fibre (1000X)

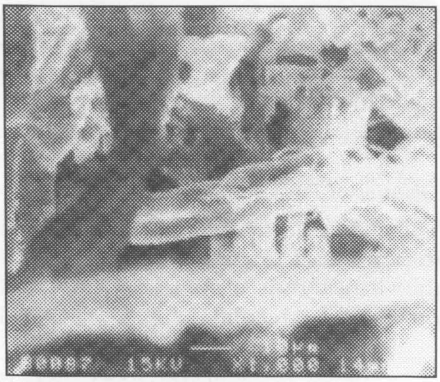

Plate 4: Recovered Malaysian fibre 1000X

Chemical Analysis of Fibre

The imported traditional fibre is cellulose based fibre which is approximately 80% cellulose, whilst the Malaysian fibre is about 65% cellulose fibre. From Fig. 1, it can be seen that the percentage distribution of Holocellulose below 200μm is almost similar. From 200μm to 600μm a linear increment is observed. However, upon approaching a percentage distribution of 77% Holocellulose stage occur to the graph before reaching its ultimate condition from 600μm.

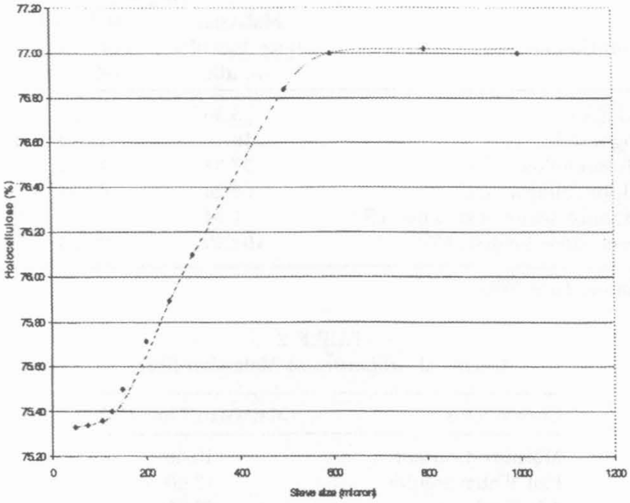

Fig. 1. % Holocellulose vs particle size

From Fig. 2, the percentage of alpha-cellulose below 200mm is constant but a gradual decrement is noticeable. From 200μm to 600μm a linear decrement is observed. However, at 600μm the graph remains constant at 62.5% alpha-cellulose.

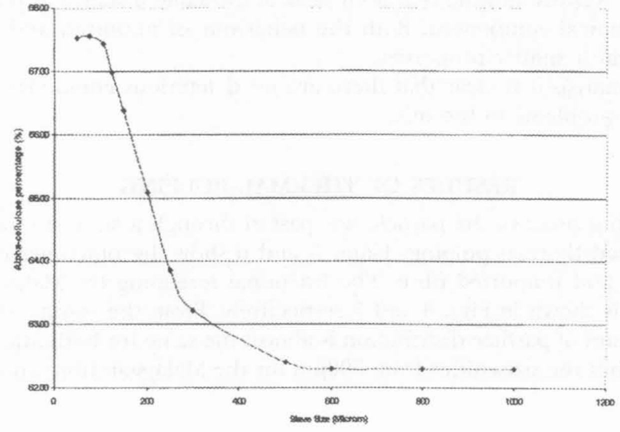

Fig. 2. % Alphacellulose vs particle size

The chemical analysis on Malaysian fibre by Liew and FRIM (1994) have been taken into consideration. This analysis was conducted to monitor the presence of any deleterious substance that would react with asphalt. Table 1 and Table 2 show the chemical composition and chemical properties of Malaysian fibre and imported fibre respectively.

TABLE 1
Chemical composition of Malaysian fibre

Constituents	Sample	
	Malaysian fibre Vascular Bundle	Malaysian fibre (after refining)
Ash(%)	3.36	3.23
Lignin(%)	19.16	17.50
Holocellulose (%)	77.04	75.33
Alpha-cellulose (%)	62.24	67.53
Ethanol-Aceton Extractive (%)	1.94	2.87
Summative analysis (%)	101.50	99.23

Source: Liew(1996)

TABLE 2
Chemical properties of Malaysian fibre

Constituents	Malaysian fibre (%)
Moisture Content	10.40
Hot Water Soluble	13.40
Alkali soluble	29.90
Alcohol benzene soluble	3.20

Source: FRIM(1994)

Pyrolysis Gas Chromatography Analysis

Figure 3 shows the mixture for both asphalt with imported fibre and asphalt with Malaysian fibre. Results indicate that both peak at the same instance as plain asphalt for the asphalt chemical component. Both the behaviour of imported and the Malaysian fibre display almost similar properties.

From this analysis it is clear that there are no deleterious components in the fibre that may cause problems to the mix.

RESULTS OF THERMAL PULPING

After the grinding process, the particle was passed through a sieve size of 500μm prior to the pressurised thermal pulping. Plates 5 and 6 show the outcomes of pulping the Malaysian fibre and iImported fibre. The fractional screening for Malaysian fibre and imported fibre is shown in Figs. 4 and 5 respectively. From the result obtain, it can be seen that the trend of particle distribution is almost the same for both Malaysian and the imported fibre but the sizes differ from 500μm for the Malaysian fibre and 50μm for the imported fibre.

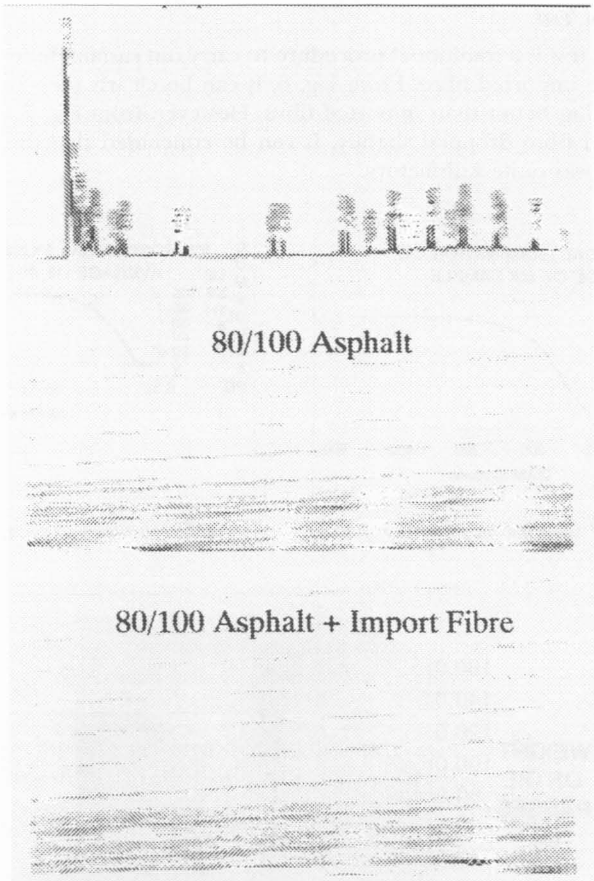

Fig. 3. Pyrolysis gas chromatograph

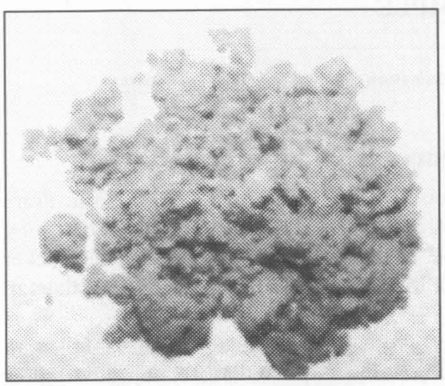

Plate 5. Pulped imported fibre

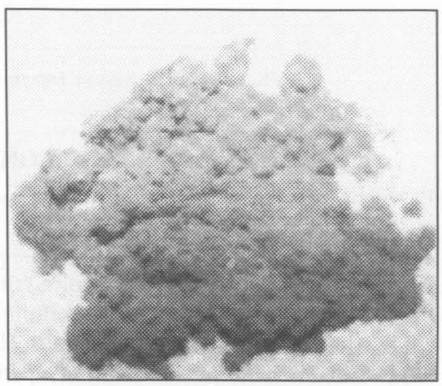

Plate 6. Pulped Malaysian fibre

Fibre Drain Down Test

The drain down test is a traditional procedure to carry out sustainability of the Malaysian fibre against the imported fibre. From Fig. 6, it can be clearly seen that the Malaysian fibre is performing better than imported fibre. However, from Fig. 7, the performance of the recovered fibre dropped slightly. It can be concluded that the performance of Malaysian fibre was quite satisfactory.

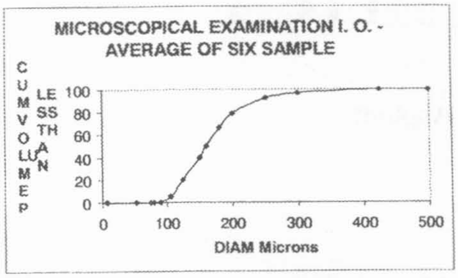

Fig. 4. Fractional screening for Malaysian fibre

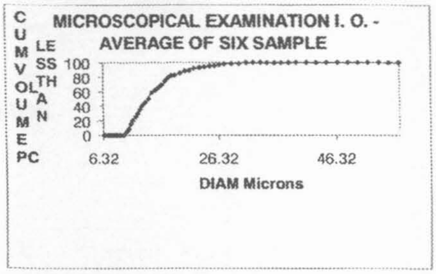

Fig. 5. Fractional screening for imported fibre

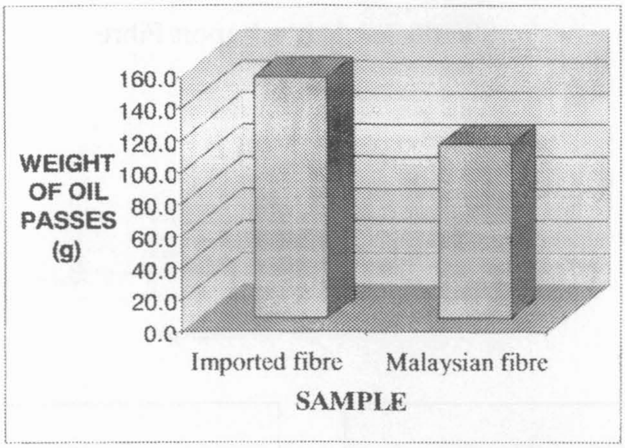

Fig. 6. Comparison between imported & Malaysian fibre vs weight of oil passes

CONCLUSION

Based on the results obtained, the following conclusions were made. Firstly, the Fibre Morphological analysis by Scanning Electron Microscope (SEM) and Fraction Screening Analysis (sieve analysis) show that the pulped Malaysian fibre seemed to be thicker (below 500mm) compared to imported fibre (below 50mm). This condition of Malaysian fibre can be improved by further pulping.

Secondly, according to the results obtained from the chemical analysis, Malaysian fibre contains cellulose content of up to 65%, whilst imported fibre contain higher cellulose of up to 80%. The advantage of the imported fibre is its soft structured nature in texture of alpha-cellulose, allowing easier expansion when heated up. This analysis also shows that the expansion of the cellulose makes the asphalt more viscous and

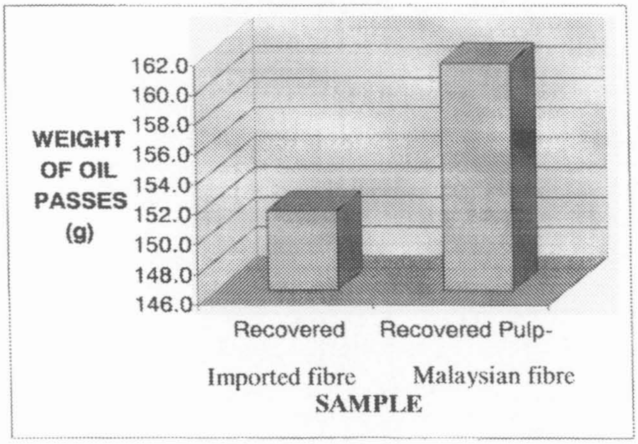

Fig. 7. Comparison between recovered imported fibre & recovered Malaysian Fibre vs weight of oil passes

provides the ability to retain the asphalt during the drain out process when temperature increases.

In the Fibre Drain Down test, by using motor oil, Malaysian fibre shows better performance than imported fibre within the allowable five minutes duration time of draining out period. There is however, a noticeable dripping of oil from Malaysian fibre indicating that it has yet to be stable. This may be assumed due to the thick presence of Malaysian fibre. This assumption can be accepted when the Recovered Fibre Drain Down Test shows a stable drain out within the allowable duration. However, the results are still inferior compared to imported fibre. Even though the drain off rate is not comparable to imported fibre but it is still acceptable because the performance of the Malaysian fibre is still within the given range, set by the European cellulose producer.

The main conclusion is that Malaysian fibre does perform comparably to imported fibre and could be an alternative supplement to replace imported fibre. However, more finding is required to improve its performance.

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