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*Development of Polymer Modified Asphalt in Malaysian Roads*

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**INTRODUCTION**

The total extent of Malaysia's road network is approximately 203,791.02 kilometres with 154,696.66 kilometres of paved road and 49,094.36 kilometres of unpaved roads [1]. Most of the paved roads in Malaysia are flexible pavement. The flexible pavement structures in Malaysia consist typically of bituminous surface, granular road base, drainage sub base and the formation subgrade. The pavement structure is designed in accordance to the *Arahan Teknik (Jalan) 5/85,*[2] which is adapted from the AASHO (American Association of State Highway Officials) Road Test. In early 2013, the standard was reviewed and the new reference for the pavement structure design was published as *Arahan Teknik (Jalan) 5/85 (Pindaan 2013):* Manual for the Structural Design of Flexible Pavement [3]. The design approach recommended in this Manual combines improved design development data and mechanistic methods of analysis into a single tool, which is presented in the form of a catalogue of pre-design pavement structures.

The asphaltic layers play a very important role in road pavement construction, i.e., providing a hard and impermeable layer to the road pavement. The hard layer prevents undue deformation in the unbound layer when subject to the traffic loading. The impermeable asphalt bound layer also prevents water from reaching the lower layer of the pavement structure, thereby weakening the layers.

The introduction of asphaltic concrete in Malaysia has brought with the problem of the extensive quality control testing, which is required to produce such mixes to the required Marshall tolerances. Even when these materials meet the specification, there are often inappropriate in areas of high traffic stresses, such as climbing lanes and main junctions, as is evident by the rapid permanent deformation along the wheel paths throughout the country. This type of deformation was called "rutting". It is hazardous to the road users as it allows surface water to accumulate, thus increasing the risk of water infiltration into the pavement structure.

Therefore in 2008, the new Standard Specification for Roadwork Section 4: Flexible Pavement was published as substitution to the previous standard, which consists of the requirement of Polymer Modified Asphalt (PMA) as an alternative in pavement construction.

## DEVELOPMENT OF POLYMER MODIFIED ASPHALT IN MALAYSIA

Polymer Modified Asphalt (PMA) concrete is an alternative to prolong the life or enhance the performance of bituminous pavement layers. It is a mixture of continuously graded aggregate and polymer modified binder. The binder is produced by incorporating an appropriate quantity of synthetic polymer to conventional bitumen. The main objective of using modified binders in asphaltic mix is to provide a cost effective solution in improving the resistance to permanent deformation of the surfacing materials at high temperature and under extreme loading condition. This can be achieved by stiffening the binder, so that the viscous response of the asphaltic mix is reduced and resulting in a corresponding reduction in permanent strain. Alternatively, when the elastic component of the binder is increased, it will reduce the viscous component, which again results in a reduction in permanent strain. Secondary benefits in terms of resistance to fatigue cracking, better load spreading ability and resistance to aging may also be achieved by putting some of the additives.

The trial on 1994 involving PMAs showed significant improvements in rutting resistance. However, cracks started to develop, after 6 months of construction in the Caribit-Plus and Chemcrete sections. Visual inspection of cores taken from the affected areas showed that the cracks originated from the top and had propagated down by no more than 20 mm. The control section for this trial had unexpectedly performed better with minimal rutting and no cracks after approximately 16 months. Subsequent tests on the mix composition showed that the binder content was 5.27%, much less than the design value of 5.95%. The improved performance could be due to the reduction of the binder content [8].

Ananother trial on using of PMA’s in 1992 was done at Bukit Tinggi on the Kuala Lumpur – Karak Highway. The climbing lane had a grade of 8 percent and the average speed of the commercial vehicles using it was uniform and measured at 15km/hr. In an experiment comparing the relative performance of a control asphaltic concrete with similar material modified with Polybilt 101 polymers, Hizam [9] reported that polymer modified asphalt performed better than the control section, reducing the rate of deformation by a factor of over 2.

In year 1996, the construction of Kuala Lumpur International Airport Runway and taxiway pavement was applying the largest amount of polymer modified asphalt. The design of bituminous binder was done using the Strategic Highway Research Program (SHRP) performance grading.

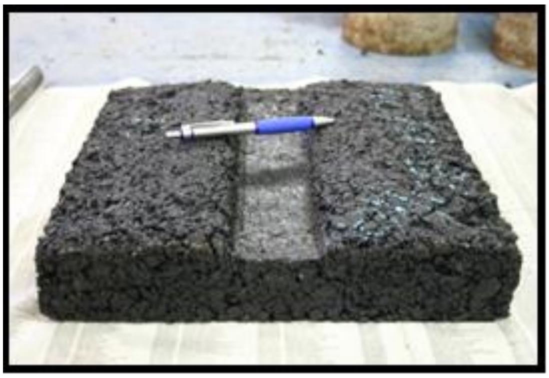
## ADVANTAGES OF POLYMER MODIFIED ASPHALT

Polymer Modified Asphalt (PMA) concrete is an alternative to prolong the life or the performance of bituminous pavement layers. It is a mixture of continuously graded aggregate and polymer modified binder (PMB). The binder is produced by incorporating an appropriate quantity of synthetic or natural polymer to conventional bitumen.

Polymer modified asphaltic concrete offers the following benefits;

i. An improved resistance to rutting.
ii. An improved resistance to fatigue cracking.
iii. An improved resistance to cracking due to binder hardening.
iv. An improved resistance to aggregate stripping
v. An improved adhesion of binder to aggregate.
vi. Reduce the thickness of asphalt layer.


**Figure 1 : Types of polymer**



Asphalt performance test using PMA has a better resistance to rutting

Asphalt performance test without PMA

**Figure 2: Effect of using polymer in asphaltic concrete mixes.**

Polymer modified binder shall be of performance grade PG 76 or higher in compliance with ASSHTO Standard M320-02. This premium grade binder shall be produced by pre-blending conventional bitumen with an appropriate quantity of synthetic polymer. It shall either be a high-shear blending equipment system provided whereby polymer modified binder can be manufactured on site, or polymer modified binder obtained from an approved source. In either case, a binder storage tank equipped with suitable mechanical agitator shall be provided close to the asphalt mixing plant. Continuous agitation during prolonged storage is essential to prevent separation of the binders. In carrying out mix design for polymer modified asphaltic concrete, additional testing are essential and these includes resilient modulus and dynamic creep. This mix is recommended for use in high stress areas such as climbing lanes or where excessive axle loads are expected. Due to relatively high cost compared to conventional asphaltic concrete, it should not be used indiscriminately.

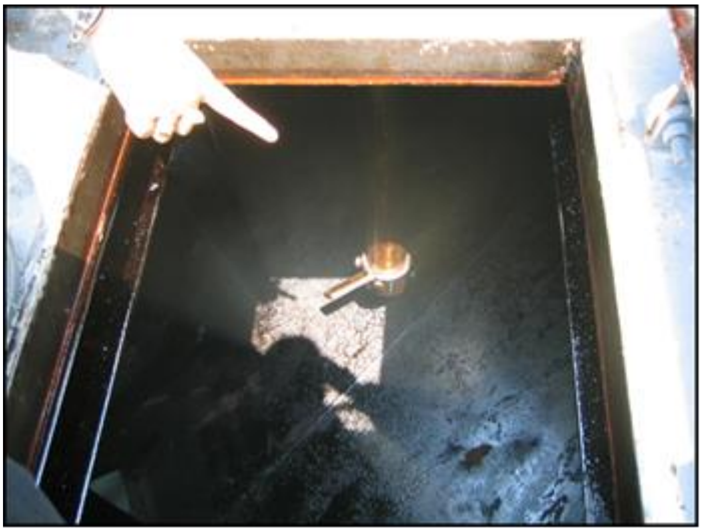


**Figure 3: Binder storage tank shall equip with suitable mechanical rotator to prevent separation of the binders during prolongs storage.**

**EXPERIMENTAL FIELD TRIAL**

Public Work Department carried out the field study on the performance of PMA in 2010. The trial site selected for the study was a 400 metres length at Bentong on Federal Route 2, Kuala Lumpur - Kuantan, Pahang. The trial was designed to compare the relative performance of a control 14mm asphaltic concrete wearing course (AC14) made with 80/100 pen bitumen, with the similar material modified with Stryrene Butadiene Styrene (SBS). The existing asphalt layer was removed and was replaced with the new wearing course layer (AC14). This field study was carried out to identify the performance of PMA on the mill and pave maintenance works.


**Figure 4: PMA Trial Section at Route 2, Bentong, Pahang**

The 200 metres of the control section was constructed to the normal contractual procedures by using 14 mm wearing course (AC14) material without any modifier. The premix of AC14 was laid at 45mm thickness while the existing layer was milled out. The 80/100 penetration grade bitumen was modified using Stryrene Butadiene Styrene (SBS) to produce Shell Chariphalte PG76 product. The SBS in Chariphalte ensure the formation of a 3 dimensional network within the bitumen, thus reducing temperature susceptibility whilst increasing stiffness modulus at high temperature as well as substantially increasing elasticity.  As same as the control section, the existing layer was removed and the premix of PMA AC14 was laid at 45mm thickness.

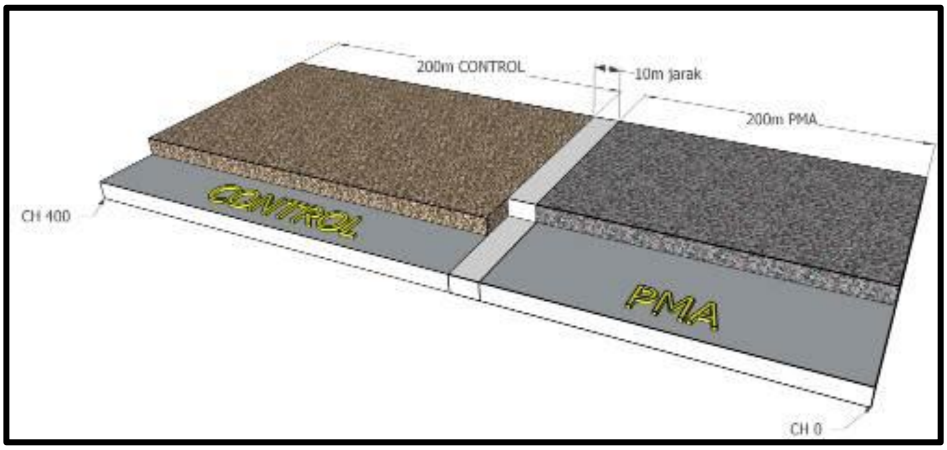



**Figure 5: PMA Trial Section at Route 2, Bentong, Pahang**

**PERFORMANCE MONITORING**

The performance of trial site was monitored for 18 months, started from the date of construction completed. The parameters that have been monitored are rutting and cracking. The maximum rut depth was measured before construction of trial section and it shows 29 mm for the Control Section and 40mm forthe PMA section. After the construction, the rut depth measurements were made at time intervals of 1 month, 2 months, 3 months, 6 months, 15 months and 18 months on both wheel paths at 10 metres spaces test point by using a 2 metres straight edge and calibrated wedge. As expected, there was no progression of ruts along both sections until 18 months.

Crack progression measurements also were made along the test section at same time interval on both wheel paths. The result showed that there was no cracks progression on the PMA test section until 18 months, after the road was constructed. As expected, the cracks were appearing on the Control test section after 15 months.



Control section

PMA Section

**Figure 6: Condition of crack progression on the control section after 18 months**

## CONCLUSIONS

The result showed that there were no rut progression on both AC14 PMA test section and control section. It also showed that the rutting does not appear on both test section. It may be due to the flat terrain of the site.

Based on 18 months of field monitoring, it showed that modified asphalt mix is able to avoid surface cracks if it is laid on a good binder course asphalt layer.

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