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EVALUATION OF RUTTING PERFORMANCE OF HOT MIX ASPHALT CONTAINING POLYMER ADDITIVES

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Abstract

In recent decades, escalating traffic volumes initiate asphalt pavements revealed to larger stresses, which can create premature distresses. To enhance the resistance to distresses, modification of the asphalt mixtures has been studied extensively. The objective of this paper is to evaluate the performance of asphalt pavement made with various bitumen types and also different thicknesses. The bitumen types used were conventional asphalt (Ac 60-70) and polymer modified asphalt (PG 76-22). The thickness of asphalt samples tested was 70, 80, and 90 mm. In this study, Accelerated Pavement Testing (APT) was conducted to evaluate the rut depth in the surface of the pavement. The experiment was run up to 20,000 cycles. The results revealed polymer has a significant effect on pavement resistance to rutting. The resistance can be increased by up to 30%. In addition, the rutting occurred rapidly for the first 3,000 cycles. Beyond 3,000, the deformation is increased slowly. On the other side, the results showed that as the HMA thickness increases as the resistance to deformation increases. We, therefore, can conclude that adding particles of polymer to HMA could improve the structural performance of pavement i.e. rutting resistance and reduce the thickness of the surface.

Research Highlights

- Effect of bitumen type and HMA thickness on perfomance of asphalt pavement were observed.
- Polymer modidifed bitumen yields the best performance. The rut depth is significantly affected by bitumen type.
- Increasing the thickness of an asphalt layer enhances the resistance of asphalt layer to the permanent deformation.

Research Objectives

Increasing traffic volumes have led to an increase in asphalt distress (1, 2). Hot mix asphalt (HMA) has been used widely to pave the roads (3). The HMA is formed with various bitumen types and aggregates (4). The bitumen has a major effect on the performance of asphalt pavement and also the binder decides the overall thickness of road pavement (5, 6). The normal (conventional) bitumen has been utilized extensively in the construction of the road; however numerous defects have been observed in the surface of asphalt pavement when the normal (unmodified) bitumen is used in the mix (7). The cracking and rutting are very common distress that occurred as a result of choosing an inappropriate bitumen type (8).

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Several studies have been carried out to assess the significance of binder types on the behavior of pavement. A study was done on conventional asphalt (grade 40-50) and asphalt modified with SBS specimens show that the rutting is highly affected by binder type (9). Moreover, another study emphasized that bitumen treated with waste cooking oil significantly improve the pavement resistance to deflection (10). However, the earlier studies have not tested the effect of bitumen types on the structural performance of asphalt pavements with varying the thickness of HMA. Therefore, the current study aimed to evaluate the structural performance of flexible pavement made with different bitumen types and thicknesses. The pavement resistance to rutting, static, and dynamic loads was evaluated.

Methodology

The materials used in this experiment are bitumen and aggregate. Two types of bitumens were tested; normal (conventional) bitumen of penetration grade 60-70 and polymer modified bitumen of performance grade PG 76-22. The aggregate used in the mix has a maximum size of 10 mm. The dense grade mix was selected to form HMA samples. The asphalt mix samples were prepared with different thicknesses i.e. 70, 80, and 90 mm. The HMA specimens were prepared in accordance with Marshal and ASTM standards. The polymer was added to asphalt mix by the wet process with a content of 20 % of total mix weight as found to be optimum in an earlier study (11). From Marshall, the optimum bitumen content for conventional asphalt mix and the polymer-modified mix was 6.2 and 5.7 % respectively.

Experiments have been conducted to assess the structural performance of HMA. Accelerated Pavement Testing (APT) was conducted to determine the rut depth in the surface of the pavement. The APT was run up to 20,000 cycles. Hot mix asphalt was placed in the machine's platform. The model of asphalt has a dimension of 1 m width and 10 m length. The thickness of HMA was varied in each trial. A loaded wheel was run with a speed of 0.2 m/s over the asphalt model and permanent deformation was measured by a dial gauge linked to a data logger. The tire pressure applied to the model was 600 kPa which is identical to the highest legally permitted tire pressure on the road vehicle. The rut depth was measured at 1,000, 3,000, 6,000, 8,000, 12,000, and 20,000 cycles.

Results

The Accelerated Pavement Testing (APT) has been done on specimens of HMA. The test was carried out to determine the permanent deformation of asphalt mixtures. The samples were altering the bitumen type and thickness. Figures 1 and 2 show the result of this test. The figures exemplify the relationship between the rutting and the number of cycles of the loaded tire. It is clear that as the number of tire cycles increases, the rut depth increases. Also, it can be seen

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that rut depth is evident after a cycle of 3,000. Beyond 3,000 cycles, the permanent deformation increases slightly. Figure 3 presents the impact of bitumen type on pavement resistance to permanent deformation at the 20,000 cycles. From figure 3, it is observable that asphalt modified with polymer yields a better result. The results can be interpreted that the bitumen content in conventional asphalt mix is higher than polymer modified asphalt samples. This greater bitumen content supplies extreme plastic flow exposure. The substantially plastic susceptibility may manage to the high permanent deformation, because of too much bitumen content in the mixture which initiates the defeat of interior friction among aggregate grains and causes the loads being carried by bitumen instead of the aggregates. On the other side, it is clear that as the HMA layer gets thicker as the permanent deformation diminishes.

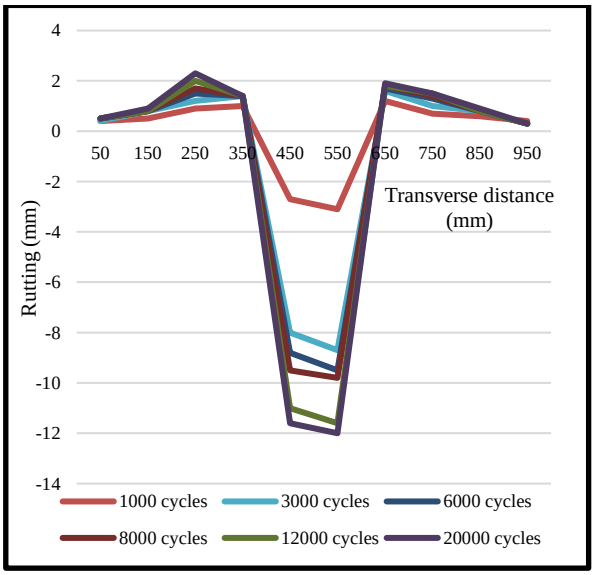

Fig. 1: Rutting in asphalt model made of AC 60-70

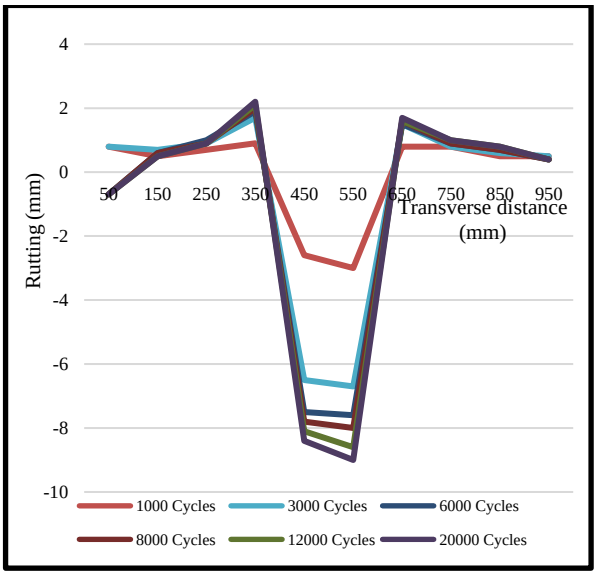

Fig. 2: Rutting in asphalt model made of PG 76-22

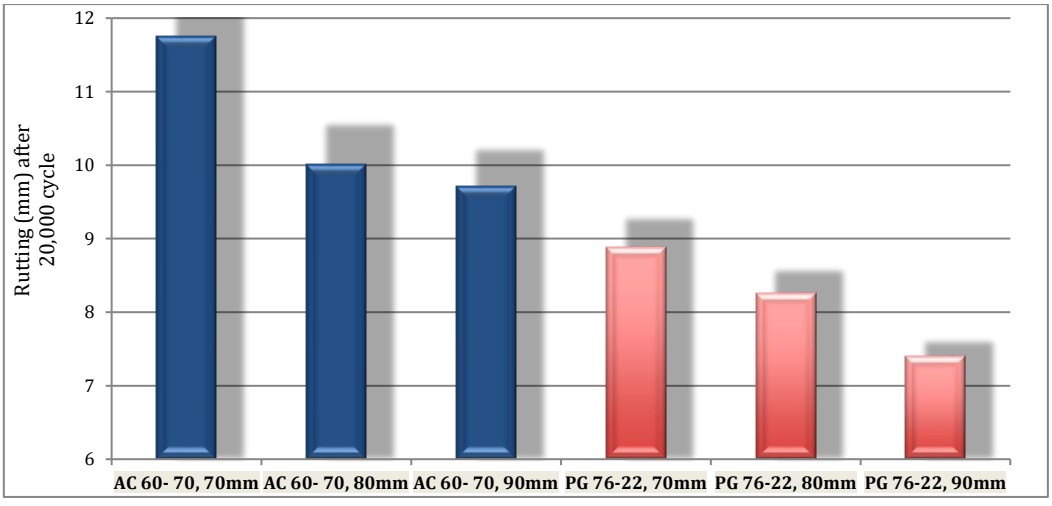

Fig. 3: Effect of bitumen type and thickness on the permanent deformation

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Conclusion

This research investigates the rutting performance of hot mix asphalt containing polymer additives. The Accelerated Pavement Testing was carried out to assess the rutting in asphalt surface. From the findings, the following conclusion can be drawn

- Polymer modified asphalt yields better resistance to rutting
- The permanent deformation can be decreased by 30% if the HMA contained polymer modifiers.
- The rut depth increases rapidly up to 3,000 cycles. However, the increase in the value of rutting is insignificant beyond 3,000 cycles.
- The thickness of the HMA layer affects greatly the structural performance of asphalt. Increasing the thickness of the HMA layer increases the resistance to the rutting.

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Author's Biography

Ahmed Salama Eltwati *received his master's degree in Highway & Transportation Eng. from Universiti Teknologi Malaysia in 2010. Then, he pursued his Ph.D. study in Highway Engineering at Universiti Teknologi Malaysia and got his Ph.D. in 2015. He has 3 years of site experience in infrastructure and building work from 2006 to 2009. He has published several Scopus/ISI indexed journals. Currently, he is the dean of the faculty of aeronautics in the Bright Star University of Libya. His research interest focuses on the development of rut and fatigue prediction models for flexible pavement and study of recyclable materials in asphalt concrete and soil.*

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