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Performance Evaluation of Flexible Pavement against Rutting

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Abstract: Asphalt is the major part of wearing surface of road structure. Asphalt plays a key role as a binder. So, it has been modified a number of times against its failures. So, modifiers like Polyethylene, crumb rubber and lime etc are added to improve its properties to increase its rut resistance. Modified asphalt is much better to control rut resistance in pavements. In this research, the performance of Polyethylene, lime and elvaloy modified asphalt is studied regarding rutting resistance and it is compared with the performance of conventional NHA (National Highway Authority Pakistan) Class-A mix .So compacted asphalt mixes were tested for resistance to rutting by subjecting all the specimens to 10,000 cycles of loaded wheel and the rut depth for each specimen was determined using wheel tracking machine. The performance of Polyethylene modified asphalt provides better resistance to rutting than all the other mixes. The conventional NHA class-A mix showed the poorest performance. The performance of polyethylene modified asphalt is better than lime modified asphalt, and elvaloy modified asphalt is better than conventional (unmodified) NHA class-A mix. Results shows that better quality asphalt concrete mixes regarding rut resistance can be prepared using lime modified asphalt, polyethylene modified asphalt and polymer modified bitumen (PMB) instead of unmodified bitumen

Keywords: *Hot Mix Asphalt (HMA), Rutting, Low Density Polyethylene (LDPE), hydrated lime, PMB, Wheel tracker.*

Introduction:

Asphalt (HMA) is the common material for road surface. It consists of crushed stone aggregates, asphalt binder and mineral filler which, in most cases, is the stone dust. The asphalt binder acts as glue and binds the aggregate particles together to form a relatively stable cohesive mass and the stone skeleton to resist the traffic load applications is provided by the aggregates. The properties of the individual components as well as the combined reaction of the system will affect the mixture performance.

Problem statement:

Rutting has become one of the major flexible pavement distresses in Pakistan in the recent years. There are many factors that contribute to the premature failure of pavement due to rutting including heavy illegal axle loading, high local temperatures, poor quality control during construction and limitations of mix design procedures to meet the requirements of Pakistani climate. Rutting is caused in the wheel paths of the vehicle which is dangerous because of hydroplaning when water is accumulated in the ruts and increase in rut depth pose safety hazards. Many modifiers are able to improve the properties of asphalt and to increase its rut resistance. Therefore lab tests should be carried out to study the rutting potential of modified asphalt mixtures using wheel tracker test.

Objectives:

The objectives of this research are:

To study the performance of polyethylene modified and lime modified HMA.

To compare the performance of asphalt mixes with unmodified and polymer modified binder of the same penetration grade.

To propose the rut resisting asphalts mixture suitable for local climate and loading conditions.

To accomplish these objectives, lab tests were conducted on various asphalt mixture at two test temperatures using wheel tracking machine.

Test Procedure:

The step by step testing procedure is given below

Sample Preparation:

Preparation of samples involve sieve analysis to separate the aggregates into frictions, mixing these fractions according to the required gradation and heating the mix along with the asphalt binder to the compaction temperature. Sieve analysis was performed manually.

Test specimens were prepared in the laboratory using Roller Compactor. The compaction of specimens by the roller compactor was done in four stages. In the first stage, the specimen was compacted under a pressure of 2 bar (200kPa) with 10 cycles of passes. In the second stage the specimen was further compacted under a pressure of 5 bar (500kPa) with 10 cycles of passes. In the 3rd stage, the specimen was further compacted under 4 bar pressure (400kPa) with 5 cycles of passes and in the 4th and final stage; the specimen was compacted under a pressure of 3 bar (300kPa) with 5 cycles of passes. Size of the specimen used was 305mm X 305mm X 50mm.Temperature of mix during compaction was 1500C. Four types of mixes were prepared and total number of samples prepared was 16.

Wheel Tracking Test:
Wheel-tracking test was used to evaluate the rutting resistance of all the mixtures. All the asphalt concrete samples were subjected to 10,000 passes of a loaded wheel at the rate of 26.5 revolutions per minute i.e. 53 passes per minute. For each mix type, out of four samples, two samples were tested at a temperature of 30 °C and the remaining two were tested at 60 °C.

Binder Extraction Test:
The binder extraction test was performed on the LDPE modified mixtures using the centrifuge extractor and chlorinated solvent (carbon tetrachloride). For the extraction purpose the compacted asphalt concrete specimen was unmolded. As the asphalt mixture was very hard and was not workable, thus it was placed in an oven. When it became hot enough to have sufficient workability, one kilogram of material was separated from it with the help of a trowel and was placed in the bowl of the extractor for the test. Then the solvent was poured onto the extraction bowl until the sample was entirely covered with it. The filter paper was placed on the bowl, the bowl was topped and the screw on the funnel clamp was tightened.

Type of Mixture	Maximum Rut Depth (mm) after 10,000 wheel passes	
	30° C	60° C
Conventional (Unmodified) NHA Class-A	2.765	6.09
Lime Modified	1.7	4.295
Mix Using PMB	1.95	3.54
Polythene Modified	1.68	2.95

Max. Rut depth in asphalt mixes at 30 and 60° C after test

Then the bowl containing the sample and solvent was placed in the machine and the lock nut was tightened. A container was placed under the drain to catch the liquid extracting from the sample and the machine was started. When the flow of solvent to the container was stopped, the centrifuge was stopped. The top and the filter paper were removed from the extraction bowl and all the clinging particles were brushed back into the bowl. The aggregates in the extraction bowl were transferred to a pan and the presence and state of LDPE was examined.

Conclusions:
In this research the effectiveness of Polythene modified, lime modified and elvaloy modified asphalt mixes was evaluated regarding rutting resistance and to compare it with the performance of conventional NHA (National Highway Authority Pakistan) Class-A mix. The specimens were tested at 30 °C and 60 °C. Major findings and conclusions of this study include the following:

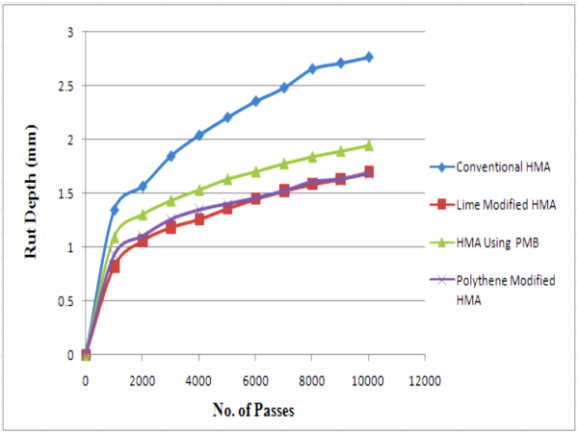

Figure 1: *Comparison of Rut Depth for Various mixes (30 °C)*

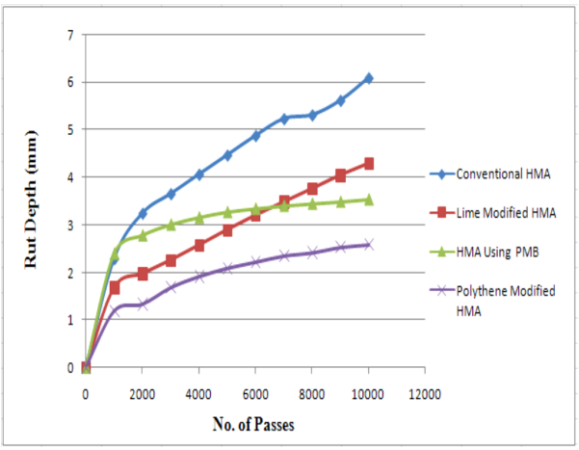

Figure 2: *Comparison of Rut Depth for Various mixes (60 °C)*

1. Rut depth increased with the increase in load repetitions and temperature for all mixes during Wheel Tracking Test.
2. At 30 °C, Polythene and lime modified mixes showed better resistance to rutting than the mix using PMB and Conventional (Unmodified) mix. The mix prepared with PMB showed better performance than Conventional mix.
3. At 60 °C Polythene modified mixes showed better resistance to rutting than all the other mixes and the conventional NHA class-A mix showed the poorest performance. The order of performance is polythene modified mix performed best, then lime modified mix, then elvaloy modified mix and then conventional (unmodified) NHA class-A mix
4. Better quality asphalt concrete mixes regarding rut resistance can be prepared using lime modified mixes, polythene modified mixes and using polymer modified bitumen (PMB) in the HMA instead of unmodified bitumen.

Recommendations:

1. The effect of modification on moisture susceptibility of asphalt mixes was not studied in this research. So, it is recommended that research should be conducted on this aspect.
2. The effect of other modifiers such as Crumb Rubber, fiber Glass etc. should be evaluated to enhance the HMA properties according to local load climatic conditions.
3. Field performance of modified asphalts should be studied.
4. Wheel tracking test can be referred as simple performance test for the comparison of rutting resistance of various asphalt mixes.

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