Study of rutting behavior of Flexible Pavement under Varying Temperatures and Bitumen Contents

Muhammad Hussain [1], Attaullah Shah [2], M. Zafar Ali Shah[3], Rashid Mehmood[3], Rana Faisal Tufail [1], Waqas Haroon[1]

[1.] Lecturer, Civil Engineering Department, Swedish College of Engineering & Technology, Wah Cantt, Pakistan.
[2.] Project Director, Allama Iqbal Open University, Islamabad, Pakistan.
[3.] Student, Civil Engineering Department, Swedish College of Engineering & Technology, Wah Cantt, Pakistan.
hussainmuhammad42@yahoo.com

Abstract: The gradual increase in traffic volume, poor design and construction practice during the last few decades in combination with an inappropriate maintenance due to Government policy has caused an accelerated and continuous deterioration of the road network in Pakistan. The increasing traffic load and compromise on quality of construction are the main causes of pavement failures, especially rutting. Maximum failure occurs due to the pavement surface exhibits wheel path depressions as a result of compaction/mix design problems. In this situation, the problem should be investigated and its proper solution should be proposed. The purpose of this research is to compare unmodified bitumen and modified bitumen (polythene modified and crumbed rubber modified).In this study, Low Density Polythene (LDP) and crumbed rubber were used as modifiers, and these modifiers were used to examine the potential prospects for improving asphalt binder properties. The proportion of bitumen content was kept as 4.5% & 5.5% by the weight of the aggregate content and in modification of polythene and crumbed rubber was kept as 0.2% by weight of bitumen content. In this study the compacted asphalt mixes were tested for resistance to rutting by subjecting all the specimens to 10,000 repetitions of a loaded wheel and the rut depth for each specimen was determined using wheel tracking machine. For the testing of these sample different temperature (25°C& 55°C) were used. A total of 12 samples have been prepared to investigate the rut depth. The result of these samples varies according to the temperature and bitumen content. This research concludes that unmodified bitumen gives less rut depth at 25°C temperature but when temperature increased up to 55°C, the crumbed rubber give better result in 4.5% bitumen content. By increasing bitumen content from 4.5 to 5.5%, polythene modified bitumen give better result in both temperature (25°C& 55°C).

[Hussain M, Shah.A, Shah.M Z A, Mehmood R, Tufail R F, Haroon W, **Study of rutting behavior of Flexible Pavement under Varying Temperatures and Bitumen Contents**. World Rural Observ 2022;14(2):58-62]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 9. doi:10.7537/marswro140221.09.

Key words: Asphalt, HMA, Flexible Pavement, Rutting

1. Introduction

Asphalt (HMA) is the common material for road surface. It consists of crushed stone aggregates, asphalt binder and mineral filler. The asphalt binder acts as a 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. Due to visco-elastic nature of asphalt binders the temperature susceptibility, aging and visco-elasticity are the important characteristics which greatly affect the asphalt binder performance. Rutting (Permanent deformation) is characterized by the surface depression along the wheel path with or without the pavement uplift along the sides of the rut. Each time when a load is applied to the pavement, a small amount of permanent deformation occurs in it. The accumulation of these small deformations after many load applications is represented by rutting. Ruts, if not very severe, are noticeable only when they are filled with water after rainfall. Rutting can be caused due to permanent deformation in the pavement Sub grade or any other layer due to the consolidation or lateral movement of the materials. Severe rutting in the pavement is an indication of its structural failure.

2. Literature Review

Musharraf Zaman et al concluded that the speed of moving vehicle has a significant role in determining rutting. From this paper he concluded that finite element based model can be used as effective tool to analyze rutting behavior of asphalt pavements. Emmanuel O et al concluded that the rutting strains of flexible pavements designed using the three known CBR methods are greater than permissible values. Kamal M.A et al in his paper concluded that resilient modulus decreases with increase in temperature from 46°C to 52°C. Ibrahim Abobaker Ali Langer et al studied that increasing load effects the pavement service life. Due to overloading the pavement service life reduced by 70% in Demak Trengguli Road section. Dar-Hao

Chen et al made an investigation to determine the root cause of the premature pavement failure. The premature pavement failure occurred in the form of rutting and alligator cracking. It was also found that the weak base is the root cause of the premature failure. It was concluded that density for construction quality control was not sufficient, as it was not able to protect against premature failures from occurring. (Musharraf Zaman et al, 2003; Emmanuel U et al, 2009; Kamal M.A et al, 2009; Ibrahim Abobaker, 2011; Dar_Hao Chen et al, 2009)

Table 1: Testing Matrix

No of Samples	Bitumen Content	Aggregate Content	Polymer (Plastic Waste)Modifier Content	Crumbed Rubber Content	Temperature
02	4.5%	95.5%	-	-	25°, 55°
02	4.3%	95.5%	0.2%		25°, 55°
02	4.3%	95.5%	-	0.2%	25°, 55°
02	5.5%	94.5%	-	-	25°, 55°
02	5.3%	94.5%	0.2%	-	25°, 55°
02	5.3%	94.5%	-	0.2%	25°, 55°

3. Objectives

The specific objectives are:

a) To study the performance of polyethylene modified and crumbed rubber modified HMA.

b) To compare the performance of asphalt mixes with unmodified, crumbed rubber modified and polymer modified binder.

c) To propose the rutting resistant asphalt mixture suitable for local climate and loading conditions

4. Methodology:

Preparation of samples involves sieve analysis to separate the aggregates into frictions. Sieve analysis was performed manually in according to NHA Class-B gradation. After the gradation of the aggregate mixing of these fractions according to the required gradation and heating the mix along with the modified asphalt binder (Polythene, Crumbed rubber) at the compaction temperature of 140 °c .Test specimens were compacted in the laboratory using Roller Compactor.

The compaction of specimens by the roller compactor was done in four stages.

a) In the first stage, the specimen was compacted under a pressure of 2 bar (200kPa) with 10 cycles of passes.

b) In the second stage, the specimen was further compacted under a pressure of 5 bar (500kPa) with 10 cycles of passes.

c) In the 3rd stage, the specimen was further compacted under 4 bar pressure (400kPa) with 5 cycles of passes.

d) In the 4th and final stage; the specimen was compacted under a pressure of 3 bar (300kPa) with 5 cycles of passes Temperature of mix during compaction was 140˚C.

After the compaction, the specimen will placed in Wheel-tracking machine to evaluate the rutting depth 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. Twelve numbers of samples were prepared in Laboratory and subjected to testing in Wheel Tracking test. Different percent content of these samples are listed below;

5. Results and Discussions

The graphs mentioned below are the comparison between the unmodified bitumen; polymer modified bitumen and crumbed rubber modified bitumen. The comparison of rutting depths between the unmodified bitumen 4.5%, polymer modified bitumen (4.3+0.2) % and crumbed rubber modified bitumen (4.3+0.2) % at temperature 25˚c, it shows that the rut depth of the unmodified bitumen 4.5% is less than the both modified bitumen (4.3+0.2) %(Fig 1). When the samples were tested at a temperature of 55˚c, it shows that the crumbed rubber modified bitumen (4.3+0.2) % has less rut depth (Fig 2). It means that to reduce the rut depth in high temperature areas, crumbed rubber modified bitumen (4.3+0.2)% will be preferred but in the regions having mostly low temperature unmodified bitumen will be preferred because it gives less rut depth. When the percent content of the modified and unmodified bitumen are increased up to 5.5% and rutting behavior, it shows that the polymer modified bitumen (5.3+0.2) % has less rut depth from both unmodified bitumen(5.5%) and crumbed rubber modified bitumen (5.3bitumen+0.2 crumbed rubber) % at both temperature 25˚c & 55˚c(Fig 3& 4).

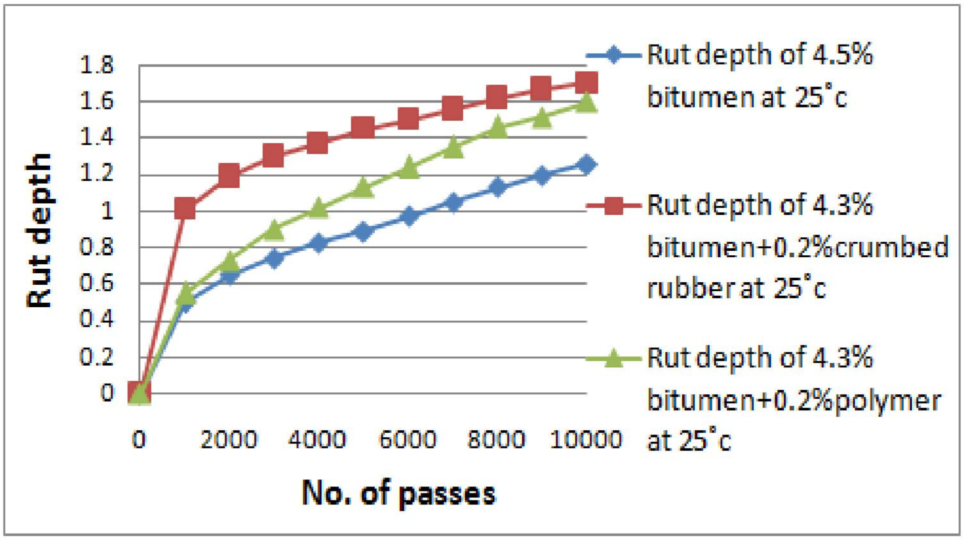

Fig 1. Relationship between number of Passes and Rut depth of various unmodified Bitumen & modified bitumen at at 25˚c

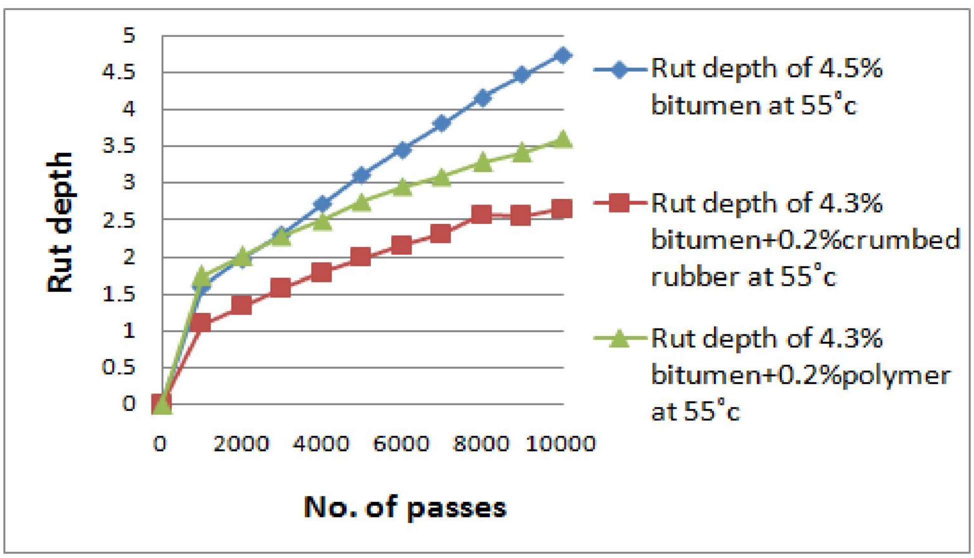

Fig 2. Relationship between number of Passes and Rut depth of various unmodified Bitumen & modified bitumen at 55˚c

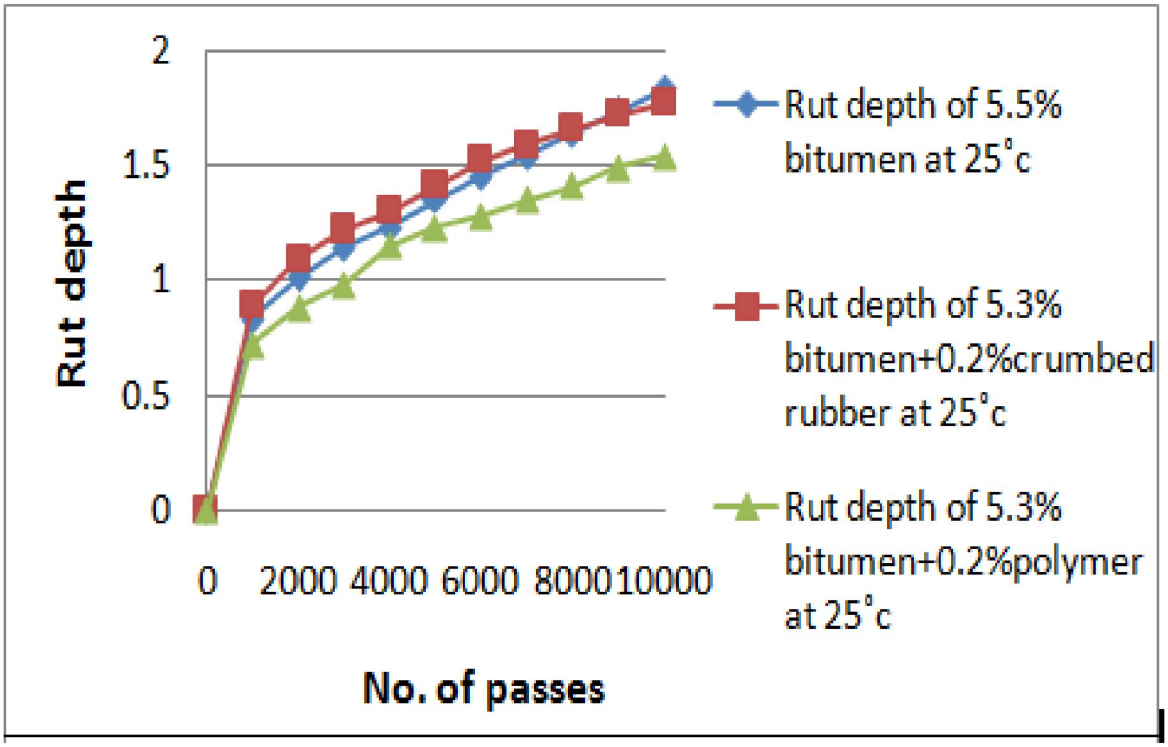

Fig 3. Relationship between number of Passes and Rut depth of various unmodified Bitumen & modified bitumen at 25˚c

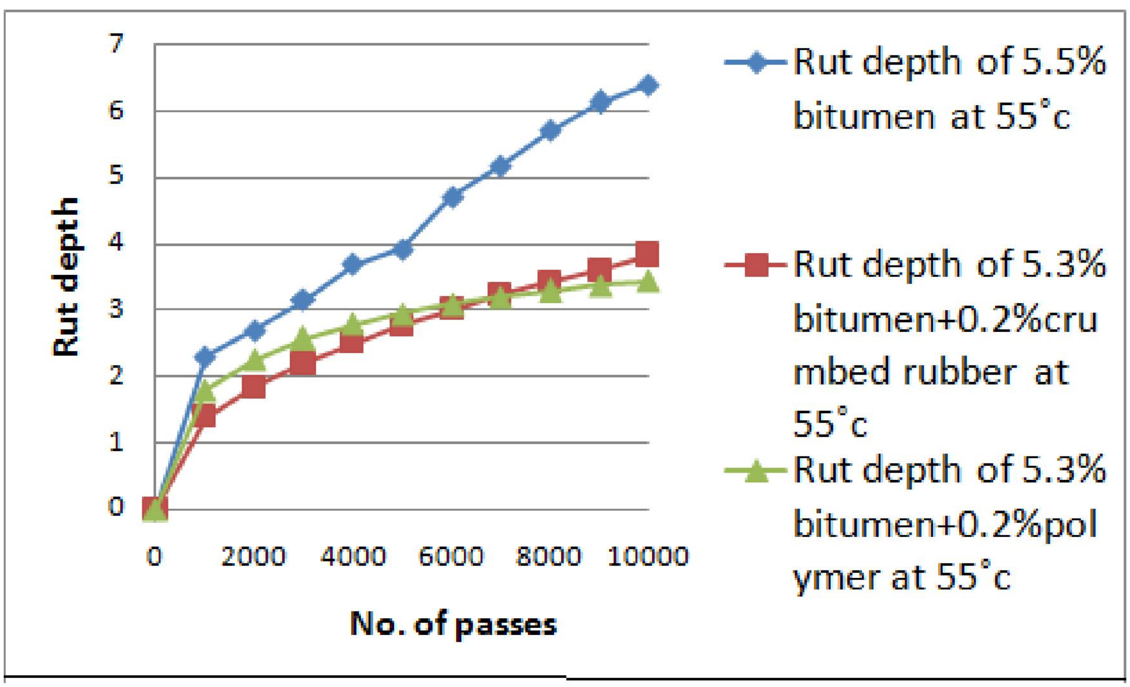

Fig 4. Relationship between number of Passes and Rut depth of various unmodified Bitumen & modified bitumen at 55˚c

6. Conclusions

a) The graphs show that, at temperature 25˚c the unmodified bitumen has less rut depth in 4.5% bitumen content but when the percentage of the bitumen is higher, then the polymer modified bitumen (5.3+0.2) % has less rut depth.

b) At the temperature 55˚c, when the percentage of the bitumen is lesser than the crumbed rubber modified bitumen (4.3+0.2)% has less rut depth but when the percentage of the bitumen is higher than the polymer modified bitumen (5.3+0.2)% has less rut depth.

7. Recommendations

a) Polymer modified bitumen is recommended at both temperature (25˚c & 55˚c) when the percent content of the bitumen is high (5.3%+0.2%).

b) Overall performance of Polythene Modified Bitumen showed better results in high percent content of bitumen than that of the conventional mix under the same loading and environmental conditions in term of permanent deformation.

8. Future Recommendations

a) There is a need of further study on different modifiers which enhance the HMA properties according to Pakistani climate (i.e. fiber Glass, HDP).

b) The current research may further be extended for varying temperature conditions and percentage of other modifiers used.

Corresponding Author:
Muhammad Hussain
Lecturer,
Civil Engineering Department
SCEAT, Wah Cantt, Pakistan.
Email: hussainmuhammad42@yahoo.com
Phone number: +92-3007105371

References

[1]. Sinan Hinislio (2004), vol. 58 "Use of waste high density polyethylene as bitumen modifier in asphalt concrete mix".

[2]. KAMAL M. A, Faisal and Babar (2005); "resilient behavior of asphalt concrete under repeated loading & effects of temperature" Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 1329 - 1343, 2005

[3]. Ibnelwaleed A. H, Wahhab H. I. A and Iqbal M. H. (2006), "Influence of Polymer Type and Structure on Polymer Modified Asphalt Concrete Mix". The Canadian Journal of Chemical Engineering, 84: 480–487. doi: 10.1002/cjce.5450840409

[4]. Abolfazl H, Hossein G and Amir A. M "Use of plastic waste (poly-ethylene terephthalate) in asphalt concrete mixture as aggregate replacement".

[5]. Ayman M. O (October 2010) "Effect of Low-Density Polyethylene on Fracture Toughness of Asphalt Concrete Mixtures" J. Mat. in Civ. Engg. Volume 22, Issue 10, pp. 1019-1024

[6]. Goodrich J. L., 1988, Asphalt and Polymer Modified Asphalt Properties Related to the Performance of Asphalt Concrete Mixes, Proc. AAPT. Vol 57.

[7]. Kamel, Nabil I., and Laverne J. Miller, 1994, "Comparative Performance of Pavement Mixes Containing Conventional and Engineered Asphalts", Transportation Research Record 1454, TRB, National Research Council, Washington, DC, pp. 172- 180.

2/21/2022