iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** IV **Month of publication:** April 2022

DOI: https://doi.org/10.22214/ijraset.2022.41732

Study and Experimental Analysis on Bitumen

Prashant Adhav[1], Akshay Bhoir[2], Ujwal Bhondiwale[3], Aniket Chikane[4], Bhavesh Kamble[5], Dr. Apeksha Mendhe[6]
[1, 2, 3, 4, 5]*Department of Civil Engineering, B. R. Harne College of Engineering & Technology, Vangani, Thane, Maharashtra, India*
[6]*Guide*

Keywords: Bitumn, Modifier, Binders, Viscosity, Mixes, Tests

I. INTRODUCTION

Bituminous mixes are used widely for paving applications in India and worldwide. Currently, the road projects in India are taken up under Design, Build Operate and Transfer (DBOT) basis. The highway designer and the agency have to ensure satisfactory performance of the pavement during the design life to meet the contractual obligations. The selection of appropriate paving binders duly considering the climatic and loading conditions and the scientific design of the thicknesses of various pavement layers dictate the serviceability of the bituminous pavements during the design life. The mechanical properties of bituminous mixes depend to a large extent on the type, quality and quantity of binder used. Defects in flexible pavements such as rutting, crack initiation and propagation occur are not only due to traffic loads but also due to the thermal susceptibility of bituminous binders. The materials that gain prominence in the area of improved pavement performance are modified bituminous binders. Modifiers in the form of polymers, natural rubber, fillers etc., are added to virgin bitumen in an attempt to improve its mechanical and thermodynamic properties. To understand the applicability and performance of these modified bituminous binders, traditional specifications based on measurements of viscosity, penetration, ductility, softening point and elastic recovery are generally not adequate. In order to relate the properties of the binder to the properties of the bituminous mixes and later to the field pavement performance, it is necessary to carry out investigations and understand the rheological behaviour of the bituminous mixes with modified bituminous binders. Investigations on the performance of bituminous mixes with different modified bituminous binders will provide the much needed information on the longevity of modified bituminous binders over conventional bitumen under different traffic, climate and environmental conditions.

II. MATERIALS

The various binders used in the present work are:

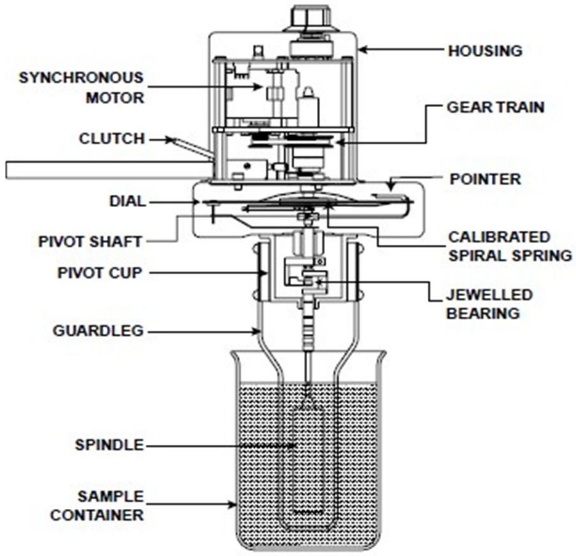
1) *Un-modified Bitumen*
   a) Viscosity Grade 30 (VG30)

2) *Modified Binders*
   a) Polymer Modified Bitumen (PMB70)
   b) Crumb Rubber Modified Bitumen (CRMB55) Natural Rubber Modified Bitumen (NRMB70)
   c) Waste Plastics Modified Bitumen (WPMB70)

Crushed granite stone aggregates were used as coarse and fine aggregates and also stone dust was used as mineral filler in the investigations carried out in this work.

A. *Viscosity Measurements Using Rotational Viscometer*

The Brookfield DV-II+Pro rotational viscometer is used in present investigations to measure the apparent viscosity at temperature regime of 135 to 180 ^{o}C. Principally, it measures the torque required to rotate an immersed element (the spindle) in a fluid (bitumen). The spindle is driven by a motor through a calibrated spring. For a given material, the viscous drag, or resistance to flow (indicated by the degree to which the spring winds up), is proportional to the spindle's speed of rotation and is related to the spindle's size and shape (geometry). The drag will increase as the spindle size and/or rotational speed increase. It follows that for a given spindle geometry and speed, an increase in viscosity will be indicated by an increase in deflection of the spring.
Measurements were made using a specified spindle (SC4-21) at different speeds to detect and evaluate the rheological properties of the binders. The Viscometer is composed of several mechanical sub-assemblies. Figure 7 shows a schematic view of the major components of a basic dial-reading Viscometer.



III. CHARACTERIZATION OF BITUMINOUS MIXTURES WITH MODIFIED BINDERS

Bituminous mixes used for paving application consists of bitumen and mineral aggregates. The bitumen acts as a binding agent to glue aggregate particles into a dense mix. Performance of in-service pavements is significantly influenced by the bitumen and aggregate system and this is achieved by ensuring proper mix design. The ease with which a laboratory designed bituminous mix can be mixed, placed and compacted in the field can be defined as workability (Marvillet and Bougault, 1978). This chapter presents the details of the investigations carried out on the bituminous mixes with modified binders in comparison with the unmodified bitumen. The performance of the bituminous mixes under loading is evaluated using a rut wheel tester under varying temperature and material states.

The aggregate gradation recommended by MoRTH 4^{th} revision for Bituminous Concrete Grade-2 surfacing course is considered in the present investigations (Table 5).

Table 5 Gradation used for the BC mix design as per MoRTH 4^{th} revision

IS Sieve (mm)	Cumulative % by weight of total aggregate passing	Adopted mid level values selected in %	Cumulative % by weight retained
19	100	100	0
13.2	79-100	89.5	10.5
9.5	70-88	79	10.5
4.75	53-71	62	17
2.36	42-58	50	12
1.18	34-48	41	9
0.6	26-38	32	9
0.3	18-28	23	9
0.15	12-20	16	7
0.075	4-10	7	9
Percentage of fines = 7 %			

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue IV Apr 2022- Available at www.ijraset.com

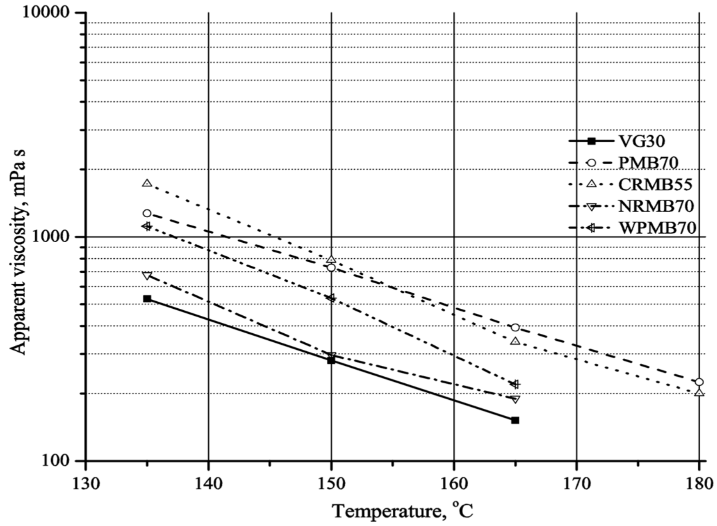


Figure Apparent viscosity and temperature relationship

Mixing and compaction temperatures are determined from the apparent viscosity and temperature relation (ASTM D2493) where the apparent viscosity of the bitumen corresponds to 0.17 ± 0.02 Pa.s for mixing and 0.28 ± 0.03 Pa.s for compaction respectively (Figure 14). As expected, modification is found to increase the viscosity of the bitumen at higher temperature. The mixing and compaction temperatures for the NRMB and WPMB were found to be comparable with unmodified VG 30 bitumen and for PMB and CRMB they are found to be higher when compared to unmodified bitumen. The higher mixing and compaction temperatures in case of modified binders are possibly due to the formations of strong polymer network and absorption of oil fractions when compared to unmodified bitumen.

Table showing Properties of bituminous mixtures designed using Superpave method

Properties/Bitumen types	VG30	PMB70	CRMB55	NRMB70	WPMB70
Optimum bitumen content, %	5.25	5.35	5.4	5.7	5.5
Effective bitumen content, %	4.24	4.37	4.36	4.27	4.40
Air voids, %	4	4	4	4	4
Voids in mineral aggregate, %	14.07	14.00	14.44	14.62	15.71
Volume of voids filled with bitumen, %	71.23	70.40	72.31	72.65	74.50
% G_{mm} (est) @ N_{ini}	82.65	88.93	88.95	88.79	88.70
% G_{mm} (est) @ N_{max}	96.58	96.41	96.55	96.45	96.49

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue IV Apr 2022- Available at www.ijraset.com

IV. CONSTRUCTION OF TEST STRETCH

A. Execution And Quality Control During Construction

Figure 35 Quality control by NH Bangalore division: Thickness, gradation, temperature

Figure 34 Overlay construction: Compaction

V. RESULT

Results And Analysis Specific Gravity Of Soil Samples
WP= 38.60 g,
WPS = 65.69 g,
WB= 156.61 g,
WA=139.37 g
WO= 65.69 – 38.60 = 27.09

A. Liquid limit and Plastic limitTest

The gravel soil used in this study was course grained soil obtained from local road routes .The soil was tested for specific gravity, liquid limit, plastic limit and grain size distribution as to be well known about physical properties of this particular soil material. From these experimental results a proper idea about the type of soil has been found.
Liquid Limit (WL): 28.92%
Plastic Limit (WP): 22.67%
Plasticity Index (IP): 8.24%

B. Grain size distribution (sieve analysis)

Different physical and building properties with the assistance of which soil can be appropriately recognized are called list properties. Soil grain property depends to singular strong grain and stays unaffected by the state in which a specific soil exists in nature. Here 2000 gm of test soil was taken and dried in broiler for 12 hours.

For the most part utilized test for grain estimate dissemination examination is sifter investigation. Eleven strainers were utilized. What's more, the outcomes from strainer investigation of the dirt are plotted on a semi-log chart with molecule distance across or the sifter estimate in X pivot and rate better in Y axis002E

C. Compaction Test

Very commonly used modified proctor test has been executed for 2000gm soil sample taken for each trial. Modified proctor test was followed according to IS standard. From this test, maximum dry density of the specimen was found to be 2.026gm./cc and OMC of 10.52

VI. CONCLUSION

1) The flexural creep stiffness was found to be significantly lower in polymer modified bitumen at a particular temperature (-10 oC) when compared to other binders considered in the study. However, other modified binders and unmodified bitumen showed comparable flexural stiffness at -10 oC.
2) Bituminous mixes with unmodified bitumen were found to be more susceptible to rutting at high temperatures when compared to mixes with modified asphalt binders.
3) SBS polymer modified bituminous mix was found to offer 4.8 times higher rut resistance when compared to unmodified bitumen mix during laboratory rutting studies.
4) Statistical model developed for deflection progression showed that structural condition of pavement structure marginally improved when polymer modified bitumen was used.
5) From the parametric analysis, it was found that an increase in pavement temperature resulted in significant reduction in the pavement rutting resistance and thereby justifying the need for modified binders on all highways for improved performance.
6) For the traffic level, climatic conditions and pavement structure considered in the theoretical analysis, it was found that the polymer modified bituminous mixes offered longer service life when compared to unmodified bituminous mix.

REFERENCES

[1] AASHTO T-283. (2003) Standard method of test for resistance of compacted asphalt mixtures to moisture-induced damage. American Association of State Highway and Transportation Officials (AASHTO), Washington DC, USA.

[2] AASHTO TP-62. (2007) Standard method of test for determining dynamic modulus of hot-mix asphalt (HMA). American Association of State Highway and Transportation Officials (AASHTO), Washington DC, USA.

[3] Abdelrahman, M. A., and Carpenter, S. H. (1999) The mechanism of the interaction of asphalt cement with crumb rubber modifier (CRM). Transportation Research Record, 1661, 106-113.

[4] Airey G. D., and Brown S. F (1998) Rheological performance of aged polymer modified bitumen. Proceedings of the Association of Asphalt Paving Technologists, 67, 66-87.

[5] Akhtarhusein, A., Joseph, L., Jorge, B. S., and Monismith, C. L. (1991)Relationships between modified asphalt binders rheology and binder-aggregate mixture permanent deformation response. Proceedings of the Association of Asphalt Paving Technologists, 60, 121-159.

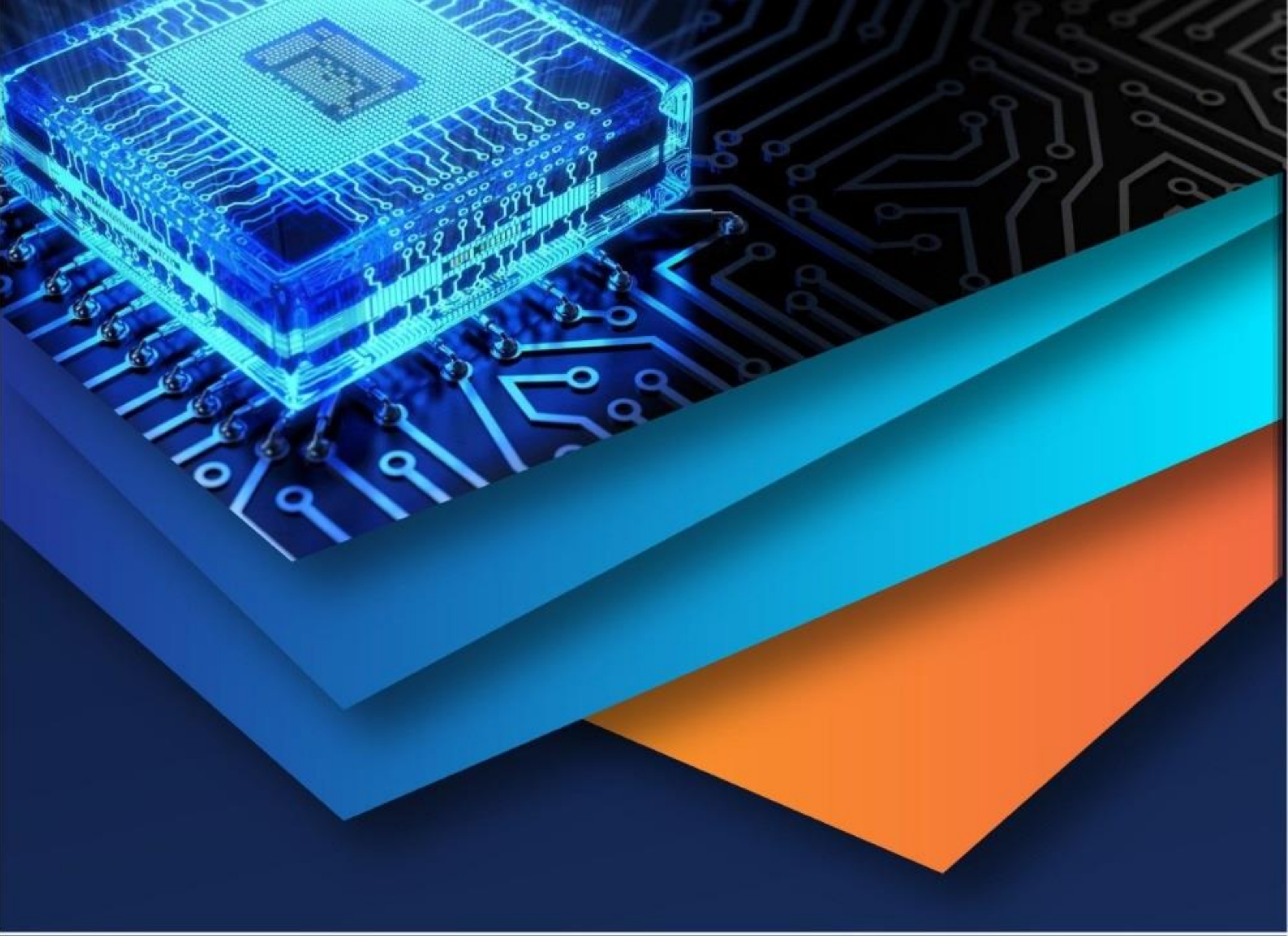
[6] Anderson, D. A., Christenen, D. W. Roque. R., and Robyak, R. K. (1992) Rheological properties of polymer modified emulsion residue. American Society of Testing Materials, ASTM STP 1108, 20-34.

[7] Anderson, D. A., Maurer, D., Ramirez, T., Christensen, D. W., Marastaena, M, O., and Mehta, Y. (1999) Field performance of modified asphalt binders evaluated with Superpave test methods. Proceedings of Annual Meeting of the Transportation Research Board, National Research Council, 78 (1661), 60-68.

[8] Anjan kumar, S., Performance and Veeraragavan, A (2010) based binder type selection using mixed integer programming technique. Construction and Building Materials, 24, 2091-2100.

[9] Asi, I. M (2007) Performance evaluation of Superpave and Marshall asphalt mix designs to suite Jordan climatic and traffic condition. Construction and Building Materials, 21, 1732-1740.

[10] Asphalt Academy. (2001) The use of modified bituminous binders in road construction. Technical Guideline, South Africa.



doi crossref
10.22214/IJRASET

INDEX COPERNICUS
45.98

JISRAF
IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY