International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST2182116

# Study of Epoxy Resin Modifies the Mechanical Performance of the Bituminous Material and Resin Modified Bituminous Mixture

**Mahesh D. Kale[1] , Dr. Bhalchandra V. Khode[2]**

[1]M.Tech Transportation Engineering, Department of Civil Engineering, G H Raisoni College of Engineering, Nagpur, Maharashtra, India

[2]Professor, Department of Civil Engineering, G H Raisoni College of Engineering, Nagpur, Maharashtra, India

**Article Info**
Volume 8, Issue 2
Page Number : 626-632

**Publication Issue**
March-April-2021

**Article History**
Accepted : 25 April 2021
Published : 30 April 2021

## ABSTRACT

India has a road network of over 4,689,842 kilometers in 2015, the second largest road network in the world. It has primarily flexible pavement design which constitutes more than 98% of the total road network. India being a very vast country has widely varying climates, terrains, construction materials and mixed traffic conditions both in terms of loads and volumes. Increased traffic factors such as heavier loads, higher traffic volume and higher tire pressure demand higher performance pavements. So to minimize the damage of pavement surface and increase durability of flexible pavement, the conventional bitumen needs to be improved. Different types of additives are currently used in bitumen for asphalt modification. Such as

I) Styrene – butadiene – styrene (SBS)
II) Natural rubber
III) Ethylene vinyl acetate (EVA)
IV) Polyethylene (PE)
V) Resin
   a) Epoxy Resin
   b) Polyurethane Resin
   c) Acrylic Resin
   d) Phenolic resin

**Keywords :** Epoxy Resin, Bitumen, Marshal Mix Design, Mechanical Properties, Stability

## I. INTRODUCTION

Resin is a sticky flammable organic substance insoluble in water exuded by some tree and other plants. Asphalt and resin are sufficient compatible with each other and is produced by mixing under heat asphalt with a condensation product of an

asphalt and a non- thermo reactive phenol resin. By this resin modification has done.

The composition gives an excellent coating without separation of asphalt on slicking based on the incompatibility of asphalt and resin. From physical and chemical interaction of Resin with conventional bitumen Resin Modified Bitumen is made. Its advantages are: Better adhesion between aggregate & binder, higher fatigue life of mixes, Prevention of cracking & reflective cracking, and Overall improved performance in extreme climatic conditions & under heavy traffic condition. The use of resin in asphalt paving is gaining more attention in many parts of the world as this material gives better mechanical and functional performance of the mixture as well as being a proficient way of dealing with this economical product. Resin modified asphalt is a general type of modified asphalt that contains Epoxy resin. Modified asphalt paving products can be made with resin by wet process. In the wet process resin modified binders are produced when it is mixed with bitumen at elevated temperatures prior to mixing with the aggregate. Binder modification of this type is due to physical and compositional changes in an interaction process where the resin particles swell in the bitumen by absorbing a percentage of the lighter fraction of the bitumen, to form a viscous gel. Bituminous binders are widely used by paving industry.

## II. METHODS AND MATERIAL

It is known from the studies that the degree of modification depends on the bitumen type and modifier type. Various studies have been done in the field of resin modification and there are several explanations for the need of using modifier in bitumen binder industry. The bitumen is available in a variety types and grades. To judge the suitability of these binders various physical tests conducted such as penetration test, ductility test, softening point test, specific gravity test, viscosity test , RTFO test, flash and fire point test. There are various reasons for using bitumen modifier in bitumen industry started with increase the service life of the pavement, improve the pavement performance, meet the heavy traffic demands, and finally saving the cost of maintenance. Marshall method of bituminous mix design is used in this study because it analyses mechanical properties such as strength and flow and volumetric properties of mix such as unit weight, air voids (VA), voids filled with bitumen (VFB) and voids in mineral aggregates (VMA).

### Mix Calculations

Marshall Stability and flow values are obtained from the Marshall Stability test and the mix calculations such as VMA, VA and VFB are calculated by using formulae. The formulae used in the mix design are given below.

Bulk specific gravity of aggregate :

$$G_{sb} = \frac{M_{agg}}{\text{volume of the (agg.mass+air void in agg.+absorbed bitumen)}} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Theoretical maximum specific gravity of the mix:

$$G_{mm} = \frac{M_{mix}}{volume\ of\ the\ (mix-air\ voids)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Bulk specific gravity of the mix:

$$G_{mb} = \frac{M_{mix}}{bulk\ volume\ of\ the\ mix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Voids in mineral aggregates:

$$VMA = \left(1 - \left(\frac{G_{mb}}{G_{sb}}\right) \times P_s\right) \times 100 \quad \text{..... (4)}$$

Air Voids:

$$VA = \left(1 - \left(\frac{G_{mb}}{G_{mm}}\right) \times P_s\right) \times 100 \quad \text{..... (5)}$$

Voids Filled with Bitumen

$$VFB = \left(\frac{VMA - VA}{VMA}\right) \times 100 \quad \text{..... (6)}$$

## III. RESULTS AND DISCUSSION

Many properties of modified mix with Epoxy resin such as Marshall Properties, Tensile Strength characteristics, Resilience Modulus, Boiling test, Retained Stability, Wheel tracking and cost-benefit analysis have been studied in this dissertation. Only VG30 grade and Epoxy resin additives has been used in this dissertation. However, some of the properties such as dynamic creep properties, Indirect fatigue test can be further be investigated. Some other type of materials such as polythene, natural rubber, Nano materials etc. can be used and other binders can also be tried in mixes and compared. Moreover, to ensure the success of this new material, experimental stretches may be constructed and periodic performances should be monitored regularly.

Various experiments have been evaluated to know the change that occurred in bitumen when Epoxy Resin is added to bitumen. The specific gravity of the Epoxy resin varies from 1.50 to 1.75 (depending on the type of production). The property of Epoxy resin shown in below the table.

**Table 1.** Properties of Epoxy resin

| **Property** | **Epoxy resin** |
|---|---|
| Viscosity at 25°C | 12000-13000 |
| Density (g.cm$^{-3}$) | 1.16 |
| Modulus of elasticity E (GPa) | 5.0 |
| Specific Gravity | 1.75 |

It has been reported that a valuable changes occur in bitumen's properties like specific gravity, penetration, penetration index, softening point, viscosity and ductility when Epoxy resin is added to bitumen in 5%, 6%, 7%, 8%, 9% and 10% by weight of bitumen. The variation in bitumen properties with the addition of Epoxy Resin.

**Marshall Properties of Unmodified Bitumen**

Marshall Parameters of ERMB-0% are graphically represented from Fig.1 to 6 as below.

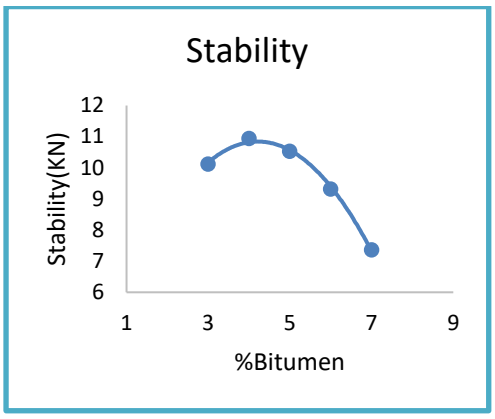


Fig. 1 Stability vs. Bitumen Content (0% Epoxy Resin)

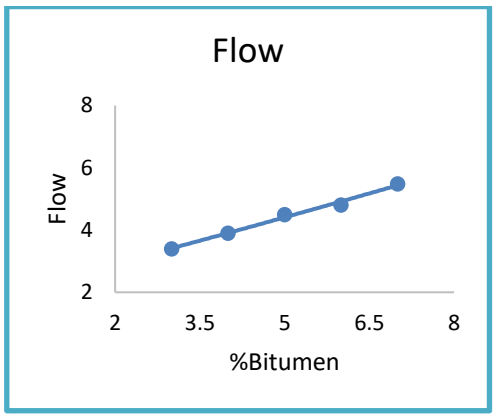


Fig. 2 Flow vs. Bitumen Content (0% Epoxy Resin)

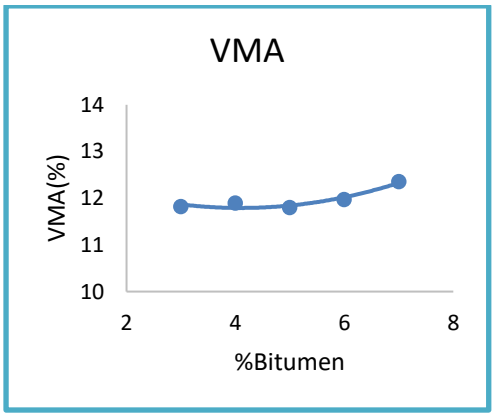


Fig. 3 VMA vs. Bitumen Content (0% Epoxy Resin)

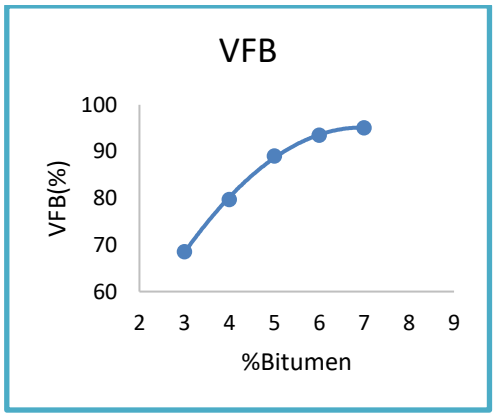


Fig. 4 VFB vs. Bitumen Content (0% Epoxy Resin)

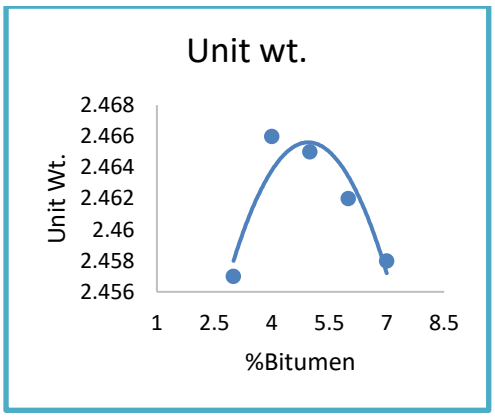


Fig. 5 Unit Wt. vs. Bitumen Content (0% Epoxy Resin)

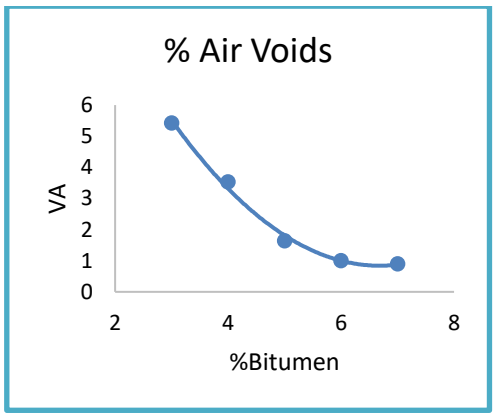


Fig. 6 VA vs. Bitumen Content (0% Epoxy Resin)

**Marshall Properties of ERMB-7%**

Marshall Parameters of ERMB-7% are graphically represented from Fig.7 to 12 as below.

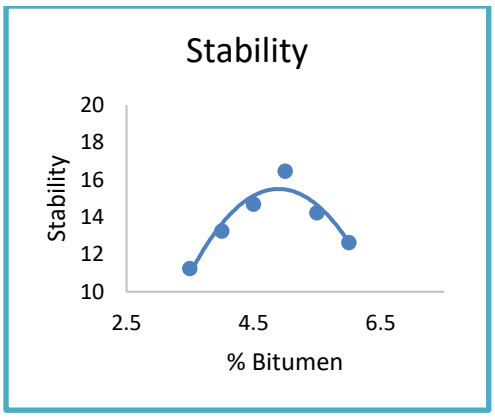


Fig.7 Stability vs. Bitumen Content (7% Epoxy Resin)

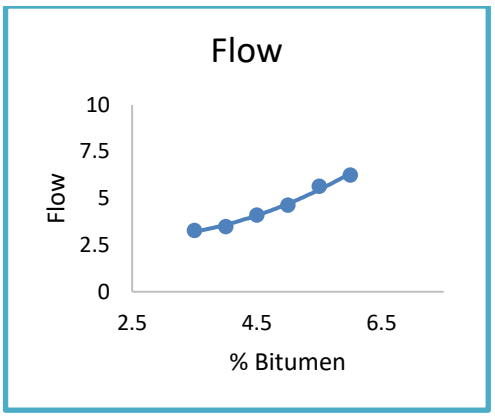


Fig. 8 Flow vs. Bitumen Content (7% Epoxy Resin)

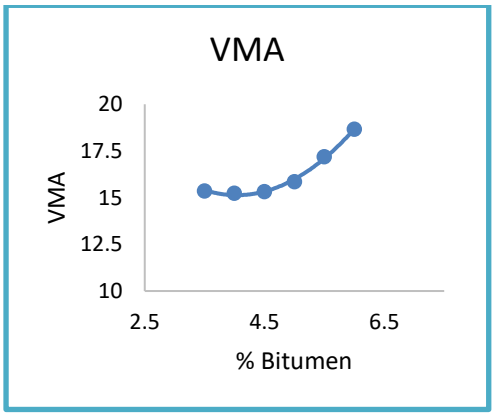


Fig. 9 VMA vs. Bitumen Content (7% Epoxy Resin)

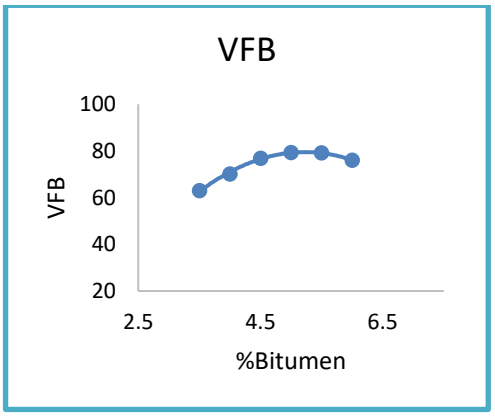


Fig. 10 VFB vs. Bitumen Content (7% Epoxy Resin)

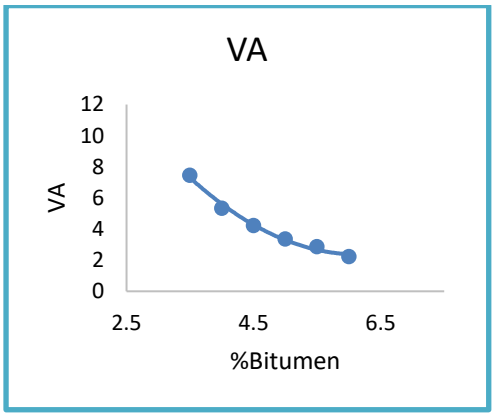


Fig. 11 VA vs. Bitumen Content (7% Epoxy Resin)

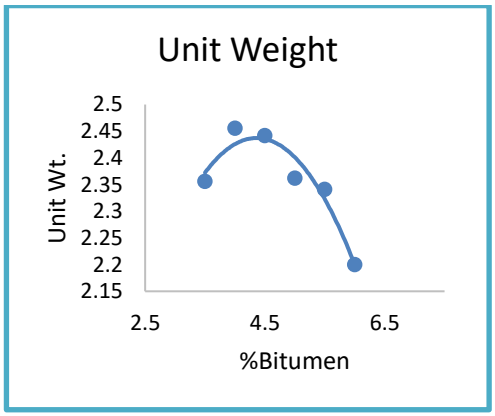


Fig12 Unit Wt. vs. Bitumen Content (7% Epoxy Resin)

Rheological test on unmodified and modified bitumen with different epoxy resin content are conducted. Rheological test such as penetration, softening point, ductility, specific gravity and viscosity tests are conducted for modified and unmodified bitumen. Adding various percentages of Epoxy resin have positive effect on the Rheological properties of bitumen.

## IV. CONCLUSION

From the study of the behavior of unmodified and modified bitumen with Epoxy resin it was found that the modifier mix process improved characteristics over unmodified mix. Some of them are listed below.

- Epoxy resin improves the physical as well as rheological behavior of binder.
- From the trends of penetration, softening point and penetration index shows that Epoxy resin modified bitumen results in improved the stiffness at lower and higher temperature. Due to the resin modified bitumen also reduces the susceptibility to temperature
- Epoxy resin modification of bitumen results in increased stiffness at lower as well as higher temperature. Temperature susceptibility of binders also gets reduced due to Epoxy resin modification.
- In the results of two RTFO procedures, lower level of aging is clearly observed at a temperature (135°C).
- It is observed that the Marshall Stability value increases with addition of Epoxy resin content to the bitumen up to 7% by weight of bitumen and then it decreases. We observer that the Marshall Flow value decreases upon addition of Epoxy resin i.e. deformations can be reduced. Due to the modification of bitumen with Epoxy resin the resistance to deformations under heavy wheel loads increases. Also the values of VMA, VFB and VA are within the required specification.
- Epoxy resin modified mixes have better resistance to thermal cracking and moisture susceptibility.
- Epoxy resin modified mixes are economically feasible to implement.
- On the basis of bitumen optimization, mechanical and volumetric parameter ERMB 7% shows the best performance while UMB is showing as least performing mix.
- Addition of Epoxy resin to bitumen increases the retained stability.
- The resilience modulus value is increased due to addition of epoxy resin to bitumen.
- The moisture susceptibility has been increased by the addition of epoxy resin to the bitumen.
- Due to addition of epoxy resin to bitumen the cost of wearing course gets decreased. The reason behind the cost reduction is mainly due to the bitumen optimization.

## V. REFERENCES

[1]. Dennis Krivohlavek, Claremore Okal, 1993, “Method of producing, using and composition of Phenolic-type resin modified asphalt or Bitumen”.

[2]. Indian Standards, “Methods of test for Aggregates for concrete: Particle size and ‘shape”, IS: 2386, Part 1, 1963.

[3]. Indian Standards,” Methods of test for Aggregates for concrete: specific gravity, density, voids, absorption and bulking”, IS: 2386, Part 3, 1963.

[4]. Indian Standards,” Methods of test for Aggregates for concrete: Impact value and Abrasion value”, IS: 2386, Part 4, 1963.

[5]. Indian Standards, “Method of test for determination of stripping value of road aggregate”, IS: 6241, 1974.

[6]. Oleg Grynyshyn, Michael Bratychak, Volodymyr Krynytskiy and Volodymyr Donchak 2008, "Petroleum Resin for Bitumen modification".

[7]. U. Isacsson, X. Lu 1995, "Testing and appraisal of phenolic resin modified road bitumen-state of the art".

[8]. Y.Xiao, M.F.C. Van de van, A.A.A. Molenaar, Z.Su.F. Zanduoort 2010, "Characteristics of two component epoxy modified resin".

[9]. Peiliang Cong, Shanfa Chen, Jianying Yu 2011, "Investigation of the Properties of Epoxy Resin-Modified Asphalt Mixture for application to Orthotropic Bridge Deck".

[10]. Pragyan Mohan 2013, "A Critical Review: The Modification, Properties, and Application of Epoxy Resin".

[11]. Heinz Lucke 1989, "Single component Polyurethane Bitumen composition".

[12]. Kenji Hijikata, Yokkaichi, Kouichi Sakaguchi, Tsu, 1982 "Epoxy Resin-Bitumen material composition".

[13]. Geoffery M. Rove, Abatech, 2015 56th Illinois Bituminous Paving Conference, "Asphalt Modification".

[14]. C. Edward Terry, Raymond A. Berard, Daniel E. Pinholster, Jr. cartersville 1999, "Polyurethane Modified Bitumen coating composition".

[15]. Shuhua Guo, Weiqui Huange, Jun Long, Ziun Wang Yucheng She 2004, "Storage-stable Modification Asphalt composition and its preparation process".

[16]. Ministry of Road Transport & Highways (MORT & H), "Specifications for road and bridge works".

[17]. "ASTM D4123-82, standard test method for indirect tension test for resilient modulus of bituminous mixtures," in Annual Book of ASTM Standards, Road and Paving Materials, vol. 04.03, ASTM International, West Conshohocken, Pa, USA, 1995.

[18]. Michale Bratychak, 4th November 2016, "Functional petroleum resins based on pyrolysis by- products and their application for bitumen modification".

[19]. Syed Usman Husainy, (2017), Enhancement of Stabilization in Bituminous Roads using Polyethylene and Epoxy Resin.

[20]. ASTM D7064-08, standard practice for open-graded friction course (OGFC) mix design," in Annual Book of ASTM Standards, Road and Paving Materials, vol. 04.03, ASTM International, West Conshohocken, Pa, USA, 2008.

[21]. Juanyu Liu peng Li, (2012) "Low Temperature Performance of Sasobit Modified Warm mix Asphalt", American Society of Engineers,10.1061/(ASCE) MT. 1993-5533.000347.

[22]. Journal of the Indian Road Congress (2014), Volume 75-1.

[23]. Naheed Saba, (2015) "Recent advances in epoxy resin, natural fiber reinforced epoxy composites and its application".

[24]. Roadways (CIA Factbook). CIA, United States. Retrieved 3 April 2013.

[25]. www.wikipidia.com

**Cite this article as :**

Mahesh D. Kale, Dr. Bhalchandra V. Khode, "Study of Epoxy Resin Modifies the Mechanical Performance of the Bituminous Material and Resin Modified Bituminous Mixture", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 8 Issue 2, pp. 626-632, March-April 2021. Available at
doi : https://doi.org/10.32628/IJSRST2182116
Journal URL : https://ijsrst.com/IJSRST2182116