STUDY OF THE MECHANICAL PERFORMANCE OF EPOXY RESIN MODIFIED BITUMINOUS MATERIAL AND RESIN MODIFIED BITUMINOUS MIXTURE

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ABSTRACT

The second largest role natural in the world after UNITED STATE is in INDIA which has over 6331791Kilometer up to 31 December 2022. More than 98% of the total road network has basically flexible pavement design. INDIA is a big country of varying climates, construction material and variety of traffic conditions as in term of loads and volumes. The pavements of road require higher performance due to increases in traffic volume day to day and higher fire pressure caused by heavier loads. So, it is the prime duty of engineers to minimize the damage of pavement surface as well as to increase the sustainability of flexible pavement which requires modification in conventional bitumen. For asphalt modification, various type of additives are being used in bitumen now a days as below-

(i) Natural rubber
(ii) Styrene-butadiene-styrene (SBS)
(iii) Ethylene vinyl Acetate (EVA)
(iv) Polyethylene (PE)
(v) Resin
  (a) Epoxy resin
  (b) Polyurethane resin
  (c) Acrylic Resin
  (d) Phenolic Resin

Bituminous binders are normally used by paving industries widely.

METHODOLOGY AND MATERIALS

The studies comes to the point that the degree of modification depends on the type of bitumen and modifier i.e. resin quality. Many of the studies in the field of resin modification process and the result came out with various responses in context with the use of modifier in bitumen binder industry. We know that the availability of bitumen is of various types with various graves. To determine the suitability of such binders many physical tests to be conducted such as penetration test, ductility test, softening point test, specific gravity test, viscosity test, RTFO (Rolling Thin-Film Oven) test, flash and fire point test. The reason behind it the maximum use of bitumen modifier in bitumen industry due to its high level of service life of the pavement , the pavement performance improvement, suitability & sustainability as per the massive & complex traffic load demands and finally due to its economic aspect i.e. saving the cost of maintenance. In this study, Marshall Method of bituminous mix design is used because its analysis is related with mechanical properties such as strength & flow, as well as its volumetric properties such as unit weight, Air Voids (VA), voids in mineral aggregates and voids field with bitumen (VFB).

MIX CALCULATION

The Marshall Stability test determines the marshal stability and its flow values. The calculation of mix such as VMA, VA and VFB are being calculated by using formulae as given below

- **Bulk specific gravity of aggregate**

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

- **Theoretical maximum specific gravity of the mix:**

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

- **Bulk specific gravity of the mix:**

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

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 Bitumen

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

There are various properties of modified mix with epoxy resin such as Marshall properties , tensile strength characteristic , resilience modulus, boiling point, Retained stability , wheel tracking and cost benefit analysis have been studied by using VG30 grade and epoxy resin additives. However, there is a need to have an exclusive study with respect to other different properties such as dynamic creep properties, indirect fatigue test. Some other type of binders can also be tried to produce & compared by using some other type of adhesive such as polythene, natural rubber, Nano materials etc. however there should be progressive innovative research flowed by continues monitoring of performance of this new material to be carried out. There is a vast scope of development with regard to sustainability and economic aspect in context with the different type of traffic with its massive load.

Many experiments have been carried out and evaluated to find out the change in properties of bitumen on mixing epoxy resin in bitumen. The specific gravity depending on the type of its product is varies from 1.50 to 1.75.

The property of epoxy resin is shown below in the table----

Properties of Epoxy Resin

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

It has been noticed that when epoxy resin is added to bitumen in 5% 6%7%8% 9% 10% and so on by weight of bitumen, the Marshall bitumen changes its properties such as specific gravity penetration, penetration index, softening point, viscosity and ductility. The variation in bitumen properties with the addition of epoxy resin has positive effect on Rheological properties of bitumen as shown in figure annexed.

Marshall Properties of Unmodified Bitumen:

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

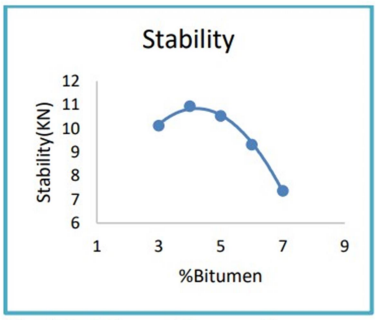

Fig. 1 Stability vs. Bitumen Content (0% Epoxy Resin)

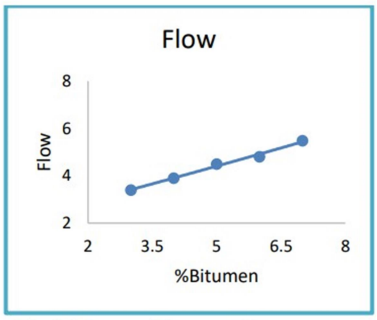

Fig. 2 Flow vs. Bitumen Content (0% Epoxy Resin)

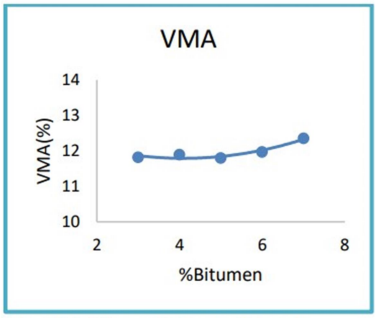

Fig. 3 VMA vs. Bitumen Content (0% Epoxy Resin)

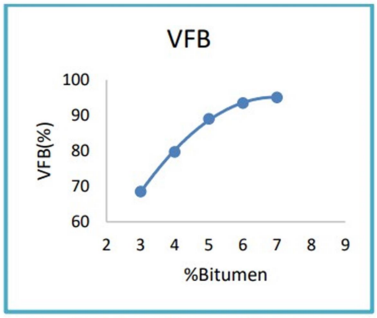

Fig. 4 VFB vs. Bitumen Content (0% Epoxy Resin)

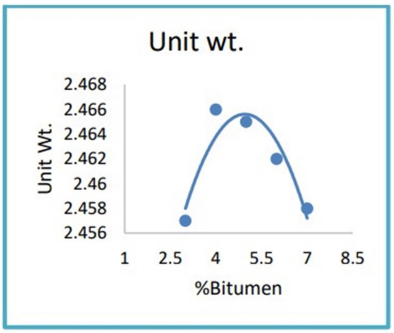

Fig. 5 Unit Wt. vs. Bitumen Content
(0% Epoxy Resin)

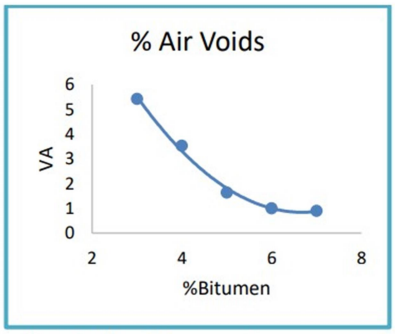

Fig. 6 VA vs. Bitumen Content
(0% Epoxy Resin)

Marshall Parameters of ERMB-7%

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

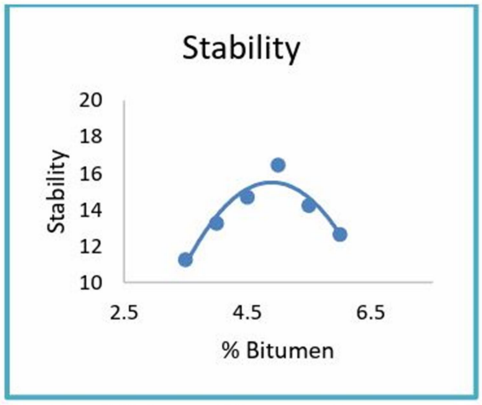

Fig.7 Stability vs. Bitumen Content
(7% Epoxy Resin)

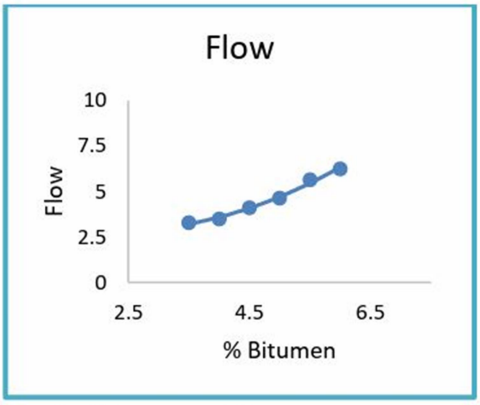

Fig. 8 Flow vs. Bitumen Content
(7% Epoxy Resin)

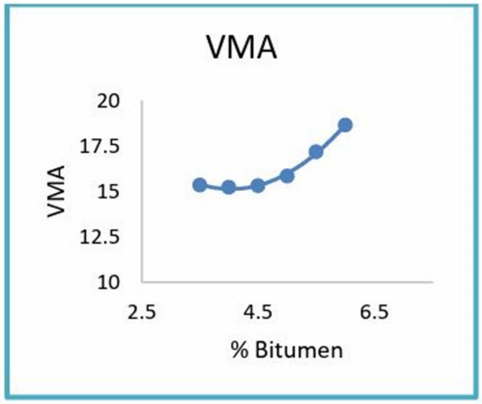

Fig. 9 VMA vs. Bitumen Content
(7% Epoxy Resin)

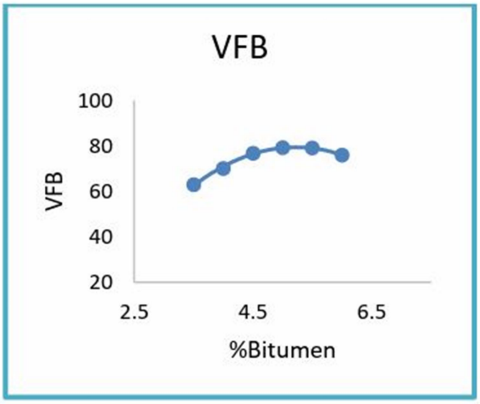

Fig. 10 VFB vs. Bitumen Content
(7% Epoxy Resin)

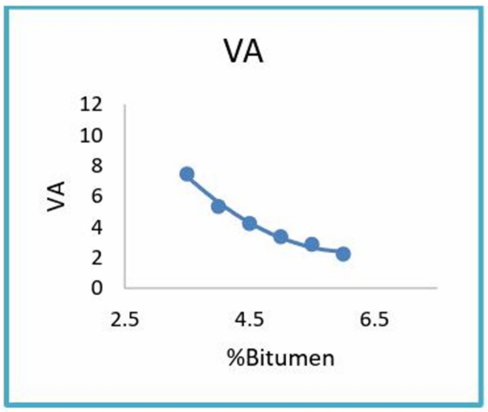

Fig. 11 VA vs. Bitumen Content (7% Epoxy Resin)

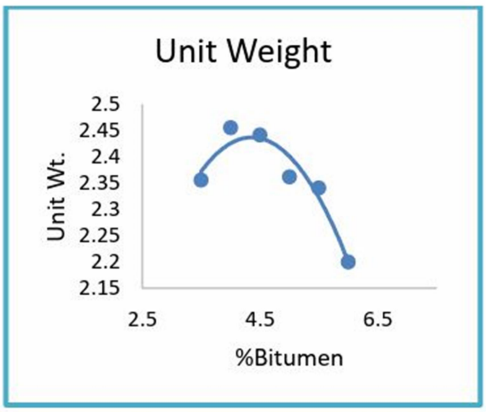

Fig12 Unit Wt. vs. Bitumen Content (7% Epoxy Resin)

CONCLUSION

The study comes to the point that when epoxy resin as modifier mix implemented in bitumen it improved the characteristics much better then unmodified mix. Some of them are given below

- Physical & rheological behavior of binder improved by applying epoxy resin.
- As per the characteristics such as penetration, softening point and penetration index, indicates that epoxy resin as modifier improved the hardening at lower temperature and higher temperature also.
- On implementing the epoxy resin as modifier, it reduce the temperature susceptibility of binders.
- Lower level of aging is observed during process of two RTFO at 135℃ temperature.
- The Marshall Stability value increases when 7% epoxy resin by weight of bitumen is mixed with bitumen and then I decreases. The Marshall Flow value also decreases by adding epoxy resin which means deformation reduced. The deformation resistant under massive wheel loads increases due to modification of bitumen with epoxy resin. Also it maintain the value of VMA, VFB, VA within the required specification.
- It is economically feasible to use epoxy resin modified mixes.
- It has better resistance of crack due to heat and moisture susceptibility.
- As per the bitumen optimization, it indicates that the best performance when 7%epoxy resin by weight of bitumen is mixed while UMB is indicating lower performing mix.
- Due to addition of epoxy resin to bitumen, the resilience modules value increases.
- It increases the retained stability on addition of epoxy resin to bitumen.
- It increases the moisture susceptibility by mixing the epoxy resin with bitumen.
- Due to the bitumen optimization on mixing the epoxy resin with bitumen the maintenance cost decreases.
- The epoxy modifier used to bitumen is very effective technology to develop long- lasting pavement materials.
- It improve the performance like higher tensile strength, flexibility and longevity enhancement.

V. REFERENCES

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