

Polymer Modified Bitumen an Experimental Study Using Epoxy Resin

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Abstract—The Modification of bitumen utilizing polymers in Road applications is picking up energy every day in the course of recent years. The requirement for the modification is raised because of the need in the enhanced execution of the flexible asphalts. Developing nations like India whose transportation primarily relies on out and about, require a tremendous research in this field. By changing the characteristics of normal bitumen with the addition of a polymer, either they are of elastomeric nature or elastomeric, we succeed to obtain bitumen that allow the mixture to be more cohesive, with much more strength and significant higher resistance to parameters like fatigue and permanent deformations for road pavements. The main thermosetting polymer used in bitumen modification is epoxy, although some polyurethane is used. Epoxy is supplied as two component system of resin and hardener which is mixed together in the bitumen. This resin and hardener ultimately react together to produce the very stiff cross linked polymer. As this is a reactive system, the relative concentrations of resin and hardener and the temperature must be carefully controlled to ensure that the mixture remains workable for a sufficient time to allow compaction. This paper studies the modification of bitumen with modifier- epoxy resin (thermosetting polymer). Different amounts of **additive yielding the best rheological and performance properties was found to be 2.6% (w/w).**

Keywords—Bitumen, Epoxy Resin, hardener, Marshal Tests, flexible pavements

1. INTRODUCTION

The most dominant mode of the vehicle in India is the Road Transport, conveying near 90% of the traveler the activity & 70% of the cargo transport. In India, Flexible pavement type of constructions are preferred over the rigid pavement type because of its different points

of interest, for example, low beginning cost, support cost, and so forth. Along these lines, among the surfaced roads, greatest is the commitment of the bituminous asphalts. Disregarding the noticeable quality of the surface transport, most of the roads are inadequately overseen and gravely maintained. Material for construction of roads, pavements and runway surfacing for quite a long while. The request of bitumen has expanded colossally in light of quick urbanization as of late. The interest for amazing tough roadway surfacing has been perpetually expanding, caused by quick debasement of the upper layers of the surface which prompts the disappointment of its waterproofing properties taken after by diminished split resistance, washboard arrangement and other ruinous components. Such climatic components as humidity, gradients, UV radiation and environmental oxygen impact the properties of asphaltic concrete. The activity stack from substantial vehicles adds to the decrease of the specialized parameters of asphaltic concrete, specifically the shear resistance and the surface unpleasantness. Innovation of roadway assurance utilizing impregnation organizations on the premise of bitumen fasteners altered with polymeric materials is a promising approach to enhance the quality and lifetime of asphalt concrete. Past works of research have affirmed that the execution of black-top can be enhanced significantly by epoxy resin.

For instance, it can diminish warm defenselessness and changeless disfigurement, increase fatigue resistance and low temperature splitting resistance, give prevalent substrate bond, and is 3-4 times more grounded than customary conventional asphalt concrete.

2. LITERATURE REVIEW

Polymer Modified bitumen expands the flexibility of the mix and furthermore builds viscosity at higher temperature (King et al., 1986). As far as possible the diversion while the flexible recuperation decreases the remaining miss happening. The flexible surface layer

connects the breaks from unmodified layers underneath, in this way, keeps up the water-tight nature of the black-top and ensures the hidden structure. King et al. (1986) additionally done a test for testing the rutting resistance and it was discovered that the PMB could withstand 4-10 times all the more loading cycles before ruts of different specified depths. Terrell and Walter (1986) have demonstrated that polymers give significant change in the physical properties of binder aggregate combinations. Be that as it may, the enhanced properties of the PMB ought to be made utilization of keeping in mind the end goal to have expanded service life and the thickness ought not be decreased on the affection of utilizing PMB.

Lenoble and Nahas (1994) demonstrated that the expansion of polymer not just increases the application temperature scope of asphaltic binders additionally increases resistance to traffic. Further, it was likewise talked about that the warm breaking resistance of an asphalt is controlled by the temperature at which the folio achieves a modulus near its polished modulus.

Airey and Brown (1998) explored chemical changes and the rheological of polymer altered bitumen under long term and short term aging conditions. The adjustments in rheology caused by aging are, diminish in penetration and increment in viscosity and softening point. It was additionally presumed that any variety in aging conduct of the PMB is because of the presence of polymer.

Khattak and Baladi (2001) demonstrated that rheological and engineering properties of polymer mixed binders rely upon the polymer type and substance. The mix design of the conventional bitumen and polymer mixed bituminous mixes were directed utilizing the Marshall Mix design methods. At the ideal polymer content, the qualities of the polymer modified mixes were around 1.45 times higher than the mixtures made with bitumen binder subjected to a similar preparing conditions. Further, experimental relations for foreseeing fatigue life of polymer modified bituminous mixes were likewise created considering diverse polymer content, plastic deformation, viscosity and tensile strength. They additionally demonstrated the change in the imperviousness to plastic distortion with polymer adjustment. It is demonstrated that the required number of load cycles to collect any estimation of plastic deformation increments as the polymer content is expanded until 5% optimum polymer content is come to. 80 Int. J. Struct. And Civil Engg. Res. 2012 Ravi.

Punith et al. (2005) contemplated the impact of different variables on versatile modulus of flexibility under repeated load tensile tests. These examinations were completed on regular 80/100 review bitumen and bitumen adjusted with polyethylene and crumb rubber

independently. It has been demonstrated that the execution of polymer adjusted bitumen with polyethylene is superior to traditional 80/100 review bitumen and binder modified with crumbed rubber

3. METHODOLOGY

To accomplish the targets of the investigation, an extensive survey is done to know about the works accessible in literature. We have to include epoxy resins in exact proportions of hardener and resin and mix them completely. After that, common tests are to be performed on aggregates and bitumen. After that epoxy resin is mixed with bitumen and research oriented laboratory tests are performed on the mixes. Finally correlation of both test outcomes with and without epoxy resin are compared.

4. MATERIALS

Aggregates

Aggregates are characterized as idle, granular, and inorganic materials that regularly comprise of stone or stone-like solids. Aggregates can be utilized alone or can be utilized with bitumen materials to shape composite materials or black-top. Around three-fourths of the volume of asphalt is involved by Aggregates. It is unavoidable that a constituent possessing such an expansive rate of the mass ought to importantly affect the properties of both the crisp and hardened product.

Epoxy Resins

Epoxy resins are a wide group of materials. The most widely recognized ones are set up from the response of bis-phenol A and epichlorohydrin and contain a receptive practical gathering in their atomic structure. Epoxy resin frameworks indicate to a great degree high three dimensional crosslink thickness which results to the best mechanical characteristics of the considerable number of resins. The most requesting quality/weight applications utilize epoxy solely. It has great quality and hardness, great heat and electrical resistance. Impediments incorporate higher cost, preparing trouble (amounts of resin and hardener should be measured decisively. Likewise, frequently warm curing is required.) Epoxy frameworks are utilized as a part of uses like aviation, safeguard, marine, sports gear, cements, sealants, coatings, design, flooring and numerous others.

Properties of Epoxy Resins:

The essential explanation behind epoxy's fame is its eminent mechanical strength. Welding is frequently the main option. Epoxy is almost constantly less expensive and speedier than welding.

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The individuals who utilize epoxy know about the heavenly mechanical strength and low curing constriction. They additionally know the epoxy resins are all around adjusted mechanical materials and suited to an expansive scope of applications. Engineers are confronted with worries about warmth dissemination, electrical protection, following unique substrates, light weighting, sound hosing, vibration, and reduction of corrosion. Appearance must be considered, and in addition, collecting costs. Epoxy is a glue detailing that meets those worries. Its warm and electrical properties, quality, and solidness are what epoxy is noted for. Those properties alongside the imperviousness to drenching and antagonistic synthetic vapor are the reason epoxy frequently is picked by engineers.

Bitumen

Bitumen is a dark or dim colored (strong, semi-strong, thick), undefined, cementitious material that can be found in various structures, such as rock asphalt, common bitumen, tar and bitumen gotten from oil, which is alluded to as petroleum bitumen. As of now the greater part of the roads all around are paved with bitumen. Today the world's interest for bitumen represents more than 100 million tons for every year which is around 700 million barrels of bitumen consumed yearly. Petroleum bitumen is ordinarily alluded to as bitumen or black-top. In Europe, for example bitumen implies the liquid fastener. In North America, then again the liquid binder is alluded to as black-top, or asphalt cement. When all is said in done the expression "bituminous materials" is utilized to signify substances in which bitumen is available or from which it can be determined. Bituminous substances involve fundamentally bitumen's and tars. Bitumen happens in nature in a few structures: hard one - effectively disintegrated bitumen in shake black-top and gentler, gooier material which is available in tar sands and black-top 'lakes'. Another path in which bitumen can be gotten is through oil handling in this way the bitumen is basically the buildup yielded through a refining procedure of oil. Despite the fact that bitumen can be found in regular shape, the world as of now depends for all reasons on oil. The material has been produced in this way for over hundreds of years. Bitumen has the following characteristic properties.

- Bitumen Adheres
- Bitumen is Elastic
- Bitumen is Plastic
- Bitumen is Viscoelastic
- Bitumen Age

- Bitumen Hardens

5. TEST RESULTS AND DISCUSSIONS

5.1 PENETRATION TEST

The values of penetration after keeping the mould in air for 1hr and then in water bath of at 30°C for 30-40 mins are noted. These reading are taken for bitumen and resin modified bitumen.

The test results of penetration are tabulated in the following TABLE-1.

% of Epoxy Resin	Dial gauge reading Initial	Dial gauge reading Final	Penetration 1/10 th mm (2-1)	Average value
0	0	48	48	46.33
	0	48	48	
	0	47	47	
1	0	52	52	53.3
	0	53	53	
	0	55	55	
2.5	0	59	59	57.6
	0	56	56	
	0	58	58	
2.6	0	67	67	66
	0	68	68	
	0	63	63	
2.8	0	53	53	54
	0	55	55	
	0	54	54	

TABLE – 1

5.2 DUCTILITY TEST

The briquette mould of length 75mm and width at mouth 20mm and at distance of 30mm each of dimensions (10x10) mm are arranged on tray. Bitumen of soft loosen state has laid on those moulds and these mould are put undisturbed for 1hr at air and later 30-40mins at 30°C in water bath. The values of bitumen,

crumb rubber modified bitumen and resin modified bitumen are noted in table-2.

%of resin	Briquette number			Mean value
	1	2	3	
0	64.5	61	63	62.83
2	61	58	65	61.3
2.5	62	63.5	66	63.83
2.6	69	71.5	68.5	69.66
2.8	61	56	57.5	61.66

TABLE – 2

5.3 VISCOSITY TEST

The viscosity of a binder is a measure of its flow characteristics, and the performance of a bituminous mix is greatly affected by its viscosity. The equipment is used for kinematic viscosity measurement. Using the equipment within the range of 20 to 100°C, temperature is controlled to 0.01°C; above 100°C temperature is controlled to 0.03°C. Various proportions of resins are mixed with bitumen and results are tabulated in table-3.

S.NO		Bulb b	Bulb c
1	Specific test temperature in degrees	60	60
2	Actual test temperature	60	60
3	Flow time in seconds (t)	63.76	128.99
4	Calibration factor k	48.1	21.8
5	Viscosity in poises	3067	2812
6	Average viscosity in poises	2990	

TABLE – 3

5.4 SOFTENING POINT TEST

Softening point means the temperature at which the bitumen achieves a specific level of softening under the determinations of test. The test is led by utilizing Ring and Ball mechanical assembly. A metal ring containing test of bitumen is suspended in fluid like water or glycerin at a given temperature. A steel ball is put upon

the bitumen test and the fluid medium is warmed at a rate of 5°C every moment. Temperature is noted when the diminished bitumen touches the metal plate which is at a predefined remove underneath. For the most part, higher softening point shows bring down in temperature susceptibility and is favored in hot atmospheres. The experiment is conducted for various percentages of epoxy resins and the results are tabulated in table-4.

% of Resin	Sample no Ball no 1	Sample no Ball no 2	Average value softening point
0	49.6	49.9	49.8
1	50	50.1	50.05
2.5	52	54	53
2.6	59	61	60
2.8	53	57	55

TABLE – 4

6. ADVANTAGES OF MODIFIED BITUMEN

Properties of Modified bitumen rely on sort and amount of modifier utilized and handle embraced for their production. The focal points of modified bitumen can include the following for road works:

- Better attachment amongst totals and cover
- Lower vulnerability to temperature varieties
- Higher exhaustion life of mixes
- Better age resistance properties
- Higher imperviousness to miss happening at high asphalt temperature
- Deferral of splitting and intelligent breaking
- Improved performance of roads

7. CONCLUSION

The fundamental observational tests specifically softening point, ductility and penetration point tests are within the tolerance limits for Epoxy resin modified Bitumen utilized for flexible pavement. This comes about help us is presuming that the epoxy with bitumen demonstrates higher temperature susceptibility and lower distortion for cracking. It is seen from our thermal examinations that bitumen with epoxies has better temperature withstanding property with an

increased property of binding. Resin modified bitumen shows lower thermal deformation which will help to decrease rutting and fatigue during its performance.

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