

# Enhancement of Stabilization in Bituminous Roads using Polyethylene and Epoxy Resin

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**Abstract** - Bituminous mix is a type of construction material used for paving roads, driveways, and parking lots. It consists of stone and other forms of aggregate materials joined together by a binding agent. It provides a smoother and quieter ride than cement surfaces. In this project we have modified bitumen with the epoxy resin and High Density Poly Ethylene (HDPE) to enhance the ordinary bitumen properties in many ways. Epoxy resin is a thermosetting polymer which increases the mechanical strength of the bitumen and mineral aggregates to a considerable amount. From the results, the wear resistance and the life time of the roads is increased. The ratio of epoxy resin added to the bitumen is a mere percentage. High Density Poly Ethylene (HDPE) is a polyethylene thermoplastic made from petroleum. It has greater strength, more opaque, harder and can withstand somewhat higher temperatures, which is most wanted for our hot country. Various percentages of HDPE (5%, 10%, 15%, 20% & 25%) with Epoxy (1% & 2%) are used for the preparation of mixes with a selected aggregate grading as given in IRC Code. It was found that 20% of HDPE and epoxy content up to 2% gives better results. The roles of HDPE and epoxy resin are studied for various engineering properties by preparing Marshall Samples of BC mixtures with and without additives. Marshall Properties such as stability, flow value, net weight, air voids are used to determine optimum content of additives for the given grade of bitumen (30/40).

**Keywords:** Bitumen, HDPE, Epoxy, polymer, thermosetting, strength, thermoplastic, stability

## 1. INTRODUCTION

Bitumen is a viscous liquid consisting essentially of hydrocarbons. It is obtained by refinery process from petroleum. It is black in color and possesses water-proofing and adhesive properties. It gets soften gradually when heated by Megha Deshmukhet al. [1]. Bituminous mix made

from a blend of stone and other forms of aggregate materials joined together by a binding agent. Bituminous mix is strong enough to handle the vehicle traffic and is relatively easy to repair or finish. It's also provides a smoother and quitter ride than cement surfaces which helps to reduce noise pollution around highways and other busy roads.

The steady increase of wheel loads, tyre pressure, change in climatic conditions & daily wear and tear severely affect the performance of bituminous mix pavements. Hence any improvement in the property of the pavement is highly essential considering the present scenario.

The addition of the additives to the bitumen improves the service properties of bitumen. Adding the epoxy resin and High Density Polyethylene (HDPE) increases the stability of the bitumen. The use of this innovative technology (Addition of Epoxy resin and HDPE) not only strengthens the road construction but also increases the road life as well. By utilization of such materials would be a boon to India's hot and extremely humid climate, where temperature frequently crosses more and torrential rains create havoc, leaving most of roads with big potholes.

However, the project work is carried out to study the properties of bituminous mix (BM) mix when aggregates are heated and mixed with Epoxy resin and the HDPE. An attempt is made in the present investigation to enhance the properties of bituminous mix due to addition of the additives.

## 2. AIM AND OBJECTIVE

The aim of this study is to identify the properties of the modified bitumen with epoxy resin and HDPE. In view of this, the various objectives identified in this study are

- To improve the durability and stability of pavement.
- To study the behaviors of bituminous mix in the application of epoxy resin and HDPE.
- To check the properties of bituminous mix specimen.

- To check the strength of alternative mixed roads.
- To be suitable for all climatic conditions.
- Comparing the properties of modified bitumen with standard bitumen.

### 3. MATERIALS USED

The raw materials like Bitumen, Aggregates, Epoxy resin and High Density Poly Ethylene (HDPE) are collected and tested for various strength and stability properties.

#### 3.1 Aggregates:

The grades of aggregates and their quantities to be used for preparing Marshall Samples were used according to the chart given in the MORTH specification. So the aggregates of different grades were sieved through different IS Sieves and they were kept in different containers with proper marking.

#### 3.2 Bitumen:

The bitumen used in preparing Marshall Samples were of 30/40 penetration grade.

#### 3.3 Epoxy resin:

Epoxy resin is an additive or binding agent which is blend with concrete or bitumen to increase the strength. The epoxy resin consists of a hardener and resin. The hardener and resin are mixed in a ratio of 1: 3. Its advantages are cures at room temperature without heating and excellent chemical resistance. Epoxy resin is used in repairs to structural concrete in buildings, loading bays, bridges, roads, bonded or granolithic floor toppings etc. [1]

#### 3.4 High Density Poly Ethylene (HDPE):

High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes, and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code.

In 2007, the global HDPE market reached a volume of more than 30 million tons [2]. HDPE is known for its large strength-to-density ratio.

The density of HDPE can range from 0.93 to 0.97 g/cm<sup>3</sup> or 970 kg/m<sup>3</sup>. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE.

HDPE coating of aggregates increases abrasion and impact resistance of aggregates thus improving strength and wear resistance properties of the treated aggregates. Moreover polymer coating reduces its affinity for water and may improve stripping susceptibility.

Modification of BM, with the polyethylene binder can be considered as a solution to overcome the problems, arising because of the rapid increase in wheel loads and change in climatic conditions. The modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement. Bitumen, when blended or mixed with the polyethylene, increases the viscosity of the mix by the formation of a more internal complex structure. These results in a very tough material, with the highest impact strength of any thermoplastic presently made.

## 4. EXPERIMENTAL WORKS

To determine the behavior of bituminous mix, we have carried out some of the tests for both bitumen and aggregate. The following tests are done as per the procedure outlined in their respective code books.

### 4.1 Test on aggregate

- SIEVE ANALYSIS TEST
- WATER ABSORPTION TEST
- IMPACT TEST
- SPECIFIC GRAVITY TEST

### 4.2 Test on bitumen

- PENETRATION TEST
- SOFTENING POINT TEST
- DUCTILITY TEST
- VISCOSITY TEST
- SPECIFIC GRAVITY TEST

### 4.3 Test on bituminous mix

- MARSHALL STABILITY TEST



Figure - 1, Impact Test

S.NO	DESCRIPTION		PENETRATION	VISCOSITY		SOFTENING	DUCTILITY
	HDPE%	EPOXY%		min	sec		
1	0	0	35.37,38	1	40	56.57	NO VISIBLE SIGN OF FAILURE
2(a)	5	1	30.33,38	4	20	58.59	91,92,4,98.5
(b)	5	2	36.37,38	4	52	59.60	87.5,89,91.5
3(a)	10	1	24.25,28	7	54	68.69	88.5,89,91
(b)	10	2	18.22,25	20	15	78.79	81,84,5,86
4(a)	15	1	16.20,21	33	36	83.84	74,77,80,5
(b)	15	2	15.17,20	38	23	89.90	70.5,73,75
5(a)	20	1	14.17,19	40	21	95.96	65,67,5,69
(b)	20	2	12.13,15	43	27	NO VISIBLE SIGN OF FAILURE	56,58,62,5
6(a)	25	1	10,10.5,11.5	47	39	NO VISIBLE SIGN OF FAILURE	43,48,50
(b)	25	2	9.5,10,10.5	50	19	NO VISIBLE SIGN OF FAILURE	37,39,41

Table - 1, Results for varying percentage of additives



Figure - 2, Penetration Test

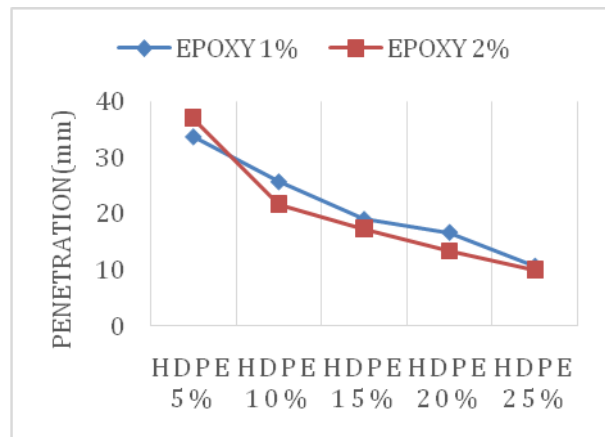


Chart - 1. Penetration values vs Hdpe & Epoxy



Figure - 3, Ductility Test

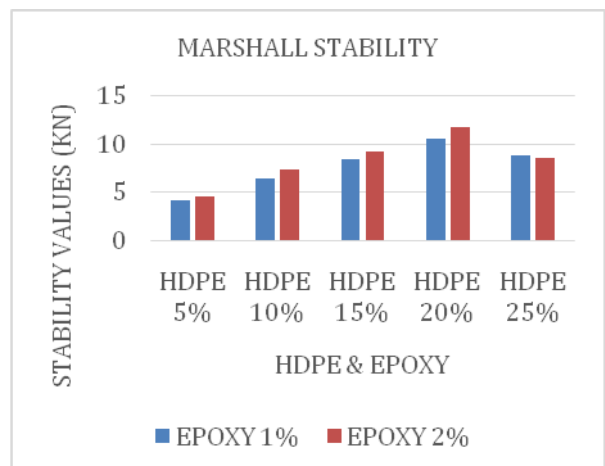


Chart - 2. Marshall Stability vs Hdpe & Epoxy

## 5. TEST RESULTS

This section includes the results for various tests carried out in this project.

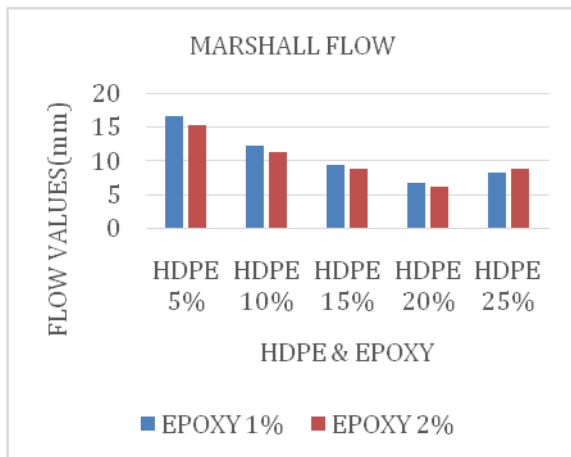


Chart - 3. Marshall Flow vs Hdpe &amp; Epoxy

- [5] IS 1206-1978 Method of testing Tar and Bituminous for determination viscosity.
- [6] IS 1203-1978 Method of testing Tar and Bituminous for determination of penetration.
- [7] IS 1205-1978 Method of testing Tar and Bituminous for determination of softening point.
- [8] IS 2386 (part 1) 1963 Method of testing an aggregate for concrete particle size and shape.
- [9] IS 2386 (part 3) 1963 Method of testing an aggregate for concrete specific gravity, absorption.
- [10] IS 2386 (part 4) 1963 Method of testing an aggregate for concrete impact value.

## 6. CONCLUSION

From this investigation, the behavior of bituminous mix with the application of high density polyethylene and epoxy resin is studied. Various percentages of HDPE (5%, 10%, 15%, 20% & 25%) with Epoxy (1% & 2%) are used for the preparation of mixes with a selected aggregate grading as given in IRC Code. It was found that 20% of HDPE and epoxy content up to 2% gives better results. This modified mix increases marshal characteristics and also the bitumen properties. Viscosity of the modified bitumen is increased when compare to the normal bitumen and the penetration value is decreased by 37.5%. Also, the softening point of modified bitumen is increased by 59%. Therefore, the percentage of HDPE increases, the hardness of the bitumen also increases and hence the ductility of the bitumen decreases. Considering the above factor we can assure that we can obtain more stable and durable mix for the pavement. This small investigation not only utilizes beneficially, the HDPE and epoxy resin provides us an improved pavement with better strength and longer life period. This modified pavement will be a boon to our extremely hot country and also heavy rainfall areas where the flexible pavements get damaged heavily. Though the HDPE and epoxy resin possess better water resisting capacity and anti-skid property. This modified pavement can be implemented in heavy traffic zones also.

## 7. REFERENCES

- [1] MeghaDeshmukh, and PrajaktaShete, "Quality Improvement Practices in Bituminous Road Construction", vol. 3, 2016.
- [2] <https://en.wikipedia.org/wiki/Epoxy>
- [3] [https://en.wikipedia.org/wiki/High-density\\_polyethylene](https://en.wikipedia.org/wiki/High-density_polyethylene)
- [4] IS 1202-1978 Method of testing Tar and Bituminous for the determination of specific gravity.