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An Experimental Investigation on Bituminous Mixes Using Low Density polyethylene Fiber

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Abstract- Generally a bituminous mix is a mixture of fine aggregate, coarse aggregate, filler and binder. A Hot Mix Asphalt (HMA) is a bituminous mixture where all constituents are mixed, placed and compacted at high temperature (HT). Waste plastic is a serious to environment. This threat has needed to find appropriate solutions for effective waste plastic management. Rapid growth of infrastructure in road construction needs natural and industries resources. In few year escalation of prizes of natural and industries resources, so that required reuse of waste material in road construction. Now-a-days disposal of different wastes produced from different Industries is a great serious problem. In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. Reuse of this material is a very simple but powerful concept. In this paper we use Low Density polyethylene (LDPE) in road infrastructure. The Waste plastic of size 3 mm to 7 mm was used to coat stone aggregates so as to make them as polymer coated aggregate before they were mixed in hot mix plant (HMP). The bitumen polyethylene coated aggregate mix, then, it was used in road infrastructure. There is a need to explore the feasibility of use of waste plastic in road infrastructure. This paper deals with study on the various test performed on Course, fine aggregates, bitumen and methodology of using waste plastic in bituminous mixes.

Keywords: Plastic waste, low density polyethylene, Aggregate, Bitumen flexible pavements.

Introduction

Most of the Highways in India constructed with flexible pavement having wearing course/surfacing course with bituminous concrete. This BC should be constructed to satisfy the recommendation and requirements of MORTH Section 509. This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layers of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100mm in thickness. As per MORTH Section 500 clause 509 BC should be made with Bitumen Grade 60/70(VG 30) for nominal aggregate size 19 mm with bitumen content 5-6% has layer thickness 50-65 mm and for nominal aggregate size 13 mm with bitumen content 5-7% having layer thickness 30-45 mm

Why use plastic:-

Polymer have a number of very important properties which exploited along or together make a Significance and expanding contribution to construction needs

- Durable and corrosion resistant
- Good insulation for cold heat and sound saving energy and reducing noise pollution
- It is economical and longer life
- Maintenance free

Plastic waste (PW) converted in the shredded form (2-8mm) was used in this study this types of plastic waste used my work.

II Need of Study

The growth in various types of industries together with population growth has resulted in enormous increase in economic activities world-wide. This has resulted in tremendous increase in the movement of people and goods, causing much stress on roads. Roads now have to be able to service large vehicular movements over diverse landscapes. It is very much desirable that lives of roads be long and requires minimal maintenance. Bitumen is most widely used for roads due to its characteristics, including- better binding property, etc. Such useful characteristics of bitumen can be further enhanced by adding modifiers to it. A number of types of materials could be used as modifier depending on their availability and the improvement it affords. Among various modifiers, polyethylene (e.g. LDPE) and crumb rubber (CRMB) based modifiers are widely used as they are easily available, as well as significantly improve road quality. The study under taken in this project will investigate preparation of LDPE/CRMB modified bitumen and improvement in its useful characteristics. This sample could be adopted to lay more resilient roads that require low maintenance and have longer life. It is also worth highlighting that the modifier added to bitumen is taken from waste materials.

III Objective

The objectives of this study are as follows:

1. To Review the relevant Literature.
2. To study the physical properties of 60/70 grade bitumen and with the varying percentage of LDPE
3. To analyze the engineering properties of modified bitumen using elastomer polythene (LDPE) materials in varying percentage and the impact of LDPE on highway bituminous mix for Dense Bitumen Concrete (DBC).

IV Scope of Study

This study will be conducted to explore the idea about use of waste material in bituminous concrete with detailed laboratory Investigation will be carry out to find whether it is viable to use or not in terms of suitability, economically and environmentally.

The present study will focus basically on these following points:

1. To study the basic physical and mechanical properties of waste plastic in order to contribute a better knowledge of its properties.
2. To study the effect on Marshall Stability of bituminous mix with the addition of waste plastic.
3. To reduce the bitumen content by the addition of Waste plastic in bituminous mix.

The laboratory investigations on the bituminous mix have been carried out as per the Indian Standards used for the road construction. The field application is out of the scope of work.

V Methodology

In this study Bituminous concrete mix has been design for 19 mm nominal size of aggregate. The Aggregate used in the study is crusher Aggregate from Quarry and VG30 60/70 grade of Bitumen used as binder. First, Laboratory testing has been carried out to find the physical properties of Aggregate by conducting tests like Grain size analysis, Aggregate Impact value, Abrasion Test, Crushing value test, Flakiness and elongation Index (combined), Water absorption, Specific Gravity etc. Also, by sieve analysis the Gradation of Aggregate has been decided which satisfied the requirement of Gradation of 19 mm nominal size of aggregate for BC design as per MORTH section 509.

Similarly, The Bitumen test for VG30 has been done including Penetration test at 25 °C, Softening Point test, Ductility test at 27 °C ,Viscosity at 150 °C, Specific Gravity etc which satisfied the requirement of IS:73-2006.

Secondly, will prepare samples for Marshall mix design and determine the Optimum bitumen content for VG30. After determining the OBC prepare sample at different % of waste plastic like 2%, 4%, 6%, 8% and based on this the Optimum waste plastic content has been determined.

Materials Used:-

(1) Aggregate	(2) Bitumen	(3) Waste Plastic
Aggregate of 20mm, 10mm,	60/70 grade bitumen	Waste plastic in the shredded

VI Test Conducted On Materials

Following tests were conducted:

(1) Penetration test, (2) Ductility test, (3)Softening point test, (4) Specific gravity test, (5) Flash and fire point test, (6) Marshal stability test

Marshall Mix Design:-

The mix design should aim at an economical blends, with proper gradation of aggregate and adequate proportion of bitumen so as to fulfil the desired properties of the mix bituminous concrete is the one of the highest and costliest types of flexible pavement layer used in surface course the desirable properties of a good bituminous mix are stability, flexibility, skid resistance, durability, workability.

Marshall Stability test Carrey out find the stability, flow value, air voids, voids fill with bitumen, density. Finally consist of an OBC, optimum plastic content and using gyratory compactor prepare performance evolution test sample.

VII Marshall Stability Test:-

This test has been carried out to determine the Optimum Binder content for BC mixes. The properties incorporate with the test are stability, flow value, Bulk specific gravity, Air voids, Voids filled with bitumen and Voids in mineral aggregate. Marshall requirement of bituminous mixes shown in Table 4 .The Voids in mineral aggregate must satisfied the requirement as shown in Table 5.

Theoretical Specific Gravity

It is the ratio of total weight of sample and sum of volume of each fraction used in the mix.

$$Gt = \frac{W1+W2+W3+W4}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{W4}{G4}}$$

Where,

Gt = Theoretical specific gravity G1 = Sp.gr. of coarse aggregate

W1 = Weight of coarse aggregate in total mix G2 = Sp.gr. of fine aggregate
W2 = Weight of fine aggregate in total mix G3 = Sp.gr. of filler material
W3 = Weight of filler material in total mix G4 = Sp.gr. of bitumen
W4 = Weight of bitumen in total mix.

Bulk Density of mix

It is the ratio of weigth in air of sample to difference in weight of sample in air and water and is denoted by Gm.

Air Voids

It is the total volume of the small pockets of air between coated aggregate particles throughout a compacted paving mixture, expressed as percentage of the total volume of the compacted paving mixture.

$$Vv = \frac{Gt - Gm}{Gt} \times 100$$

Where,
Vv = Air voids (%)
Gt = Theoretical specific gravity Gm = Bulk density of mix (g/cc)

Voids in Mineral Aggregate

It is the volume of inter granular void space between the uncoated aggregate particles of a compacted paving mixture that includes the air voids and effective bitumen content. VMA is expressed as percentage of the total volume of the compacted paving mixture.

VMA = Vv + Vb
Where,
Vv= Air voids (%)
Vb= Volume of bitumen

Voids Filled with Bitumen

It is the percentage of VMA that is occupied by the effective bitumen. $VFB = \frac{Vb}{VMA} \times 100$

Where,
Vb= Volume of bitumen
VMA= Voids in mineral aggregate.

VIII Results and Discussion

The results and analysis for ordinary bitumen mix shows that optimum binder content for the mix is 5.5% of the total weight of the aggregate. By using this optimum binder content i.e. 5.5% various samples of varying LDPE percentages (2%, 4%,6%,8%) were prepared and subsequent test have been performed to find properties of modified dense bitumen mix. The table (4.8) shows various properties of LDPE modified DBM. It has been observed that modified mix shows better properties at 8% LDPE. Now the test were performed to find the optimum binder content with 8% LDPE modified mix. The results obtained are given below in table.

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Table 1: Properties of DBM with LDPE Modified bitumen when using optimum binder content 5.5%

S.No	LDPE %	Weight of sample (gm)		Marshal stability (Kg)	Flow value (mm)	Bulk Density (gm/cc)	Air Voids %	VMA %	VFB %
		Air	Water						
1	2%	1195	690	1297	2.45	2.367	3.97	13.38	70.34
2	4%	1188	688	1345	2.57	2.376	3.85	14.60	73.63
3	6%	1186	687	1382	2.63	2.378	3.79	15.26	75.17
4	8%	1197	696	1409	2.76	2.389	3.72	16.05	76.23

Table 2: Properties of DBM with 8% LDPE modified bitumen and varying percentage of bitumen binder

S. No.	Bitumen %	Weight of sample (gm)		Marshal stability (Kg)	Flow value (mm)	Bulk Density (gm/cc)	Air Voids %	VMA %	VFB %
		Air	Water						
1	4	1193	692	1350	2.58	2.38	4.58	14.48	68.39
2	4.5	1189	690	1390	2.63	2.39	4.46	14.97	70.15
3	5	1188	693	1445	2.78	2.40	4.23	15.32	72.37
4	5.5	1195	694	1410	2.86	2.385	4.04	15.46	75.84

Following graphs have been plotted to find the optimum binder content

1. Binder content vs Marshal stability (fig. 4.6)
2. Binder content vs flow value (fig. 4.7)
3. Binder content vs Bulk Density (fig. 4.8)
4. Binder content vs Air voids (fig. 4.9)
5. Binder content vs Voids filled with bitumen (fig. 4.10)

It is observed from graphs, that maximum marshal value is obtained with 5% modified bitumen compared 5.5% ordinary bitumen in DBM.

It is therefore inferred that 8% LDPE admixture saves bitumen content, without adversely affecting Marshal Stability Value.

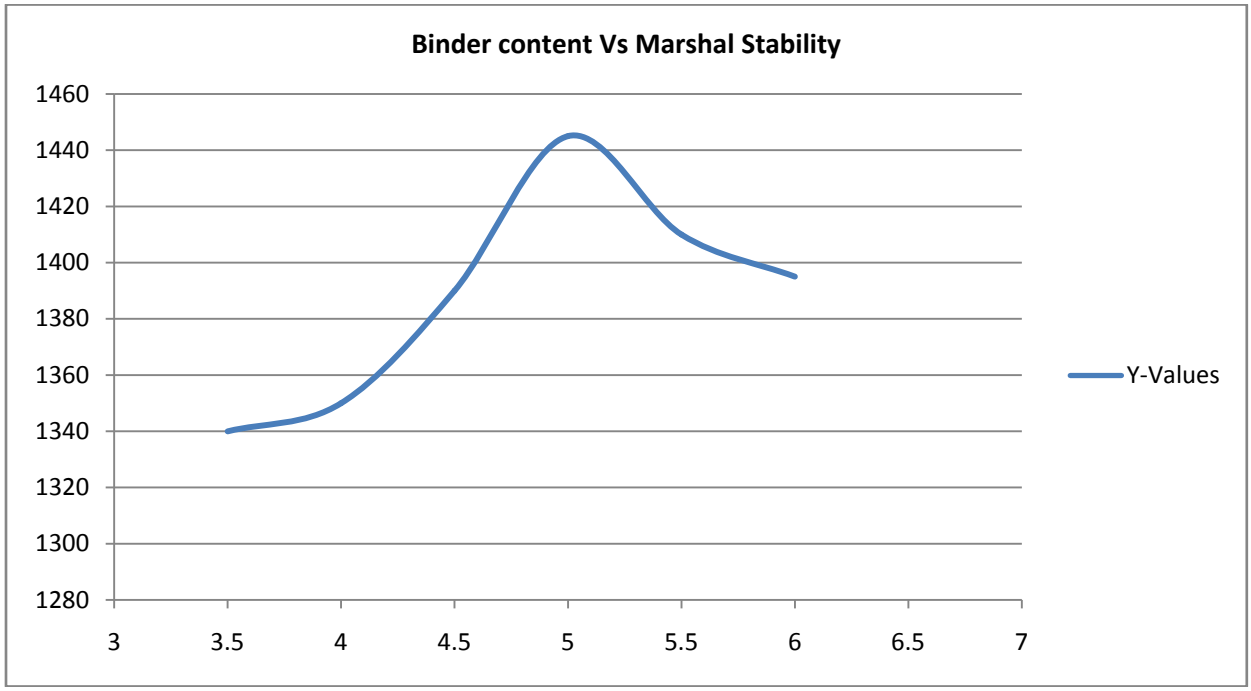

Figure1: Bitumen % Vs Marshal Stability Value.

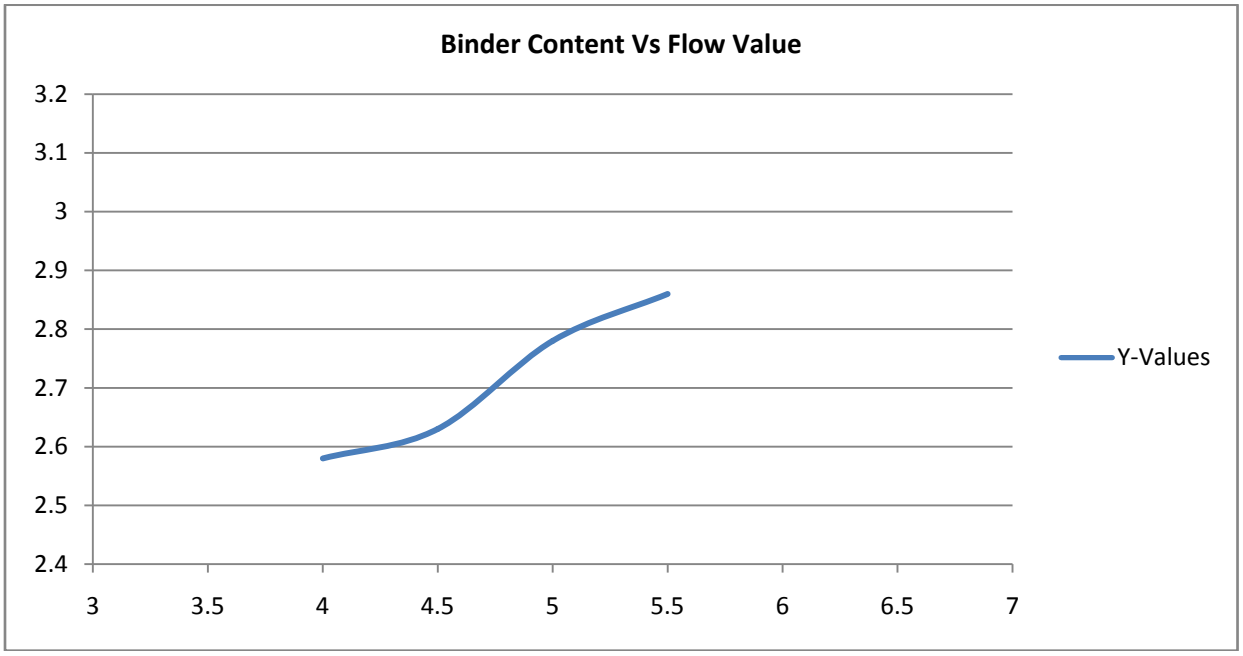

Figure 2: Bitumen % Vs Flow value.

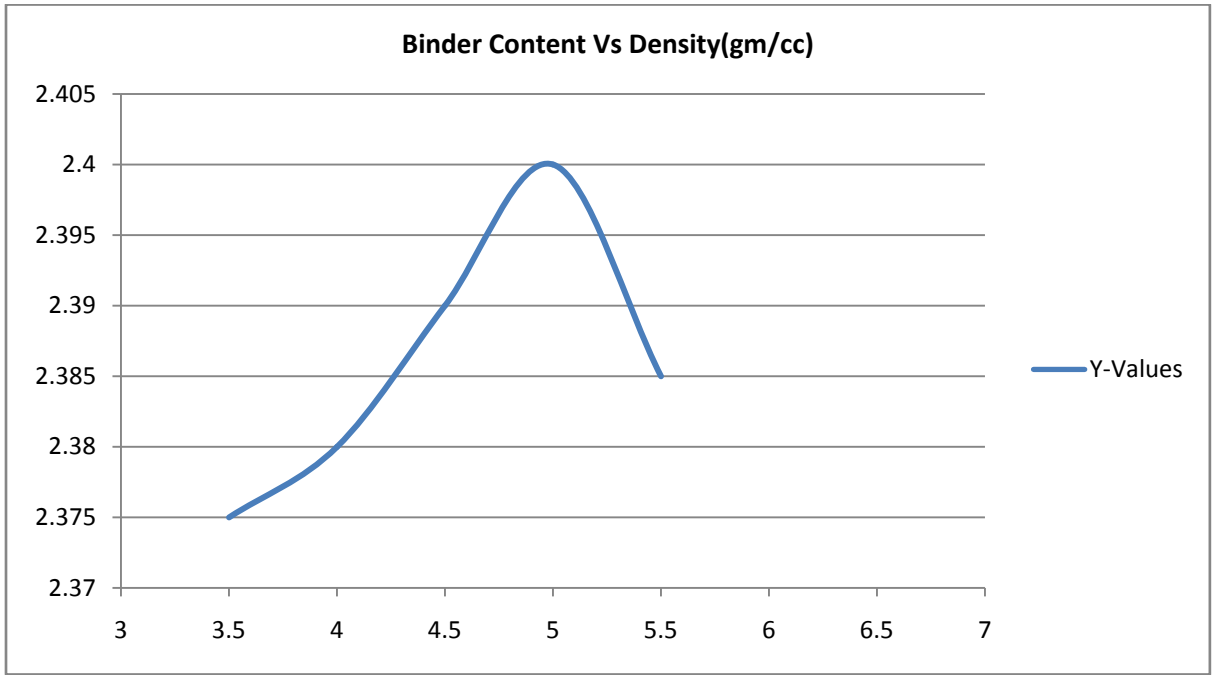

Figure 3: Bitumen % Vs Density.

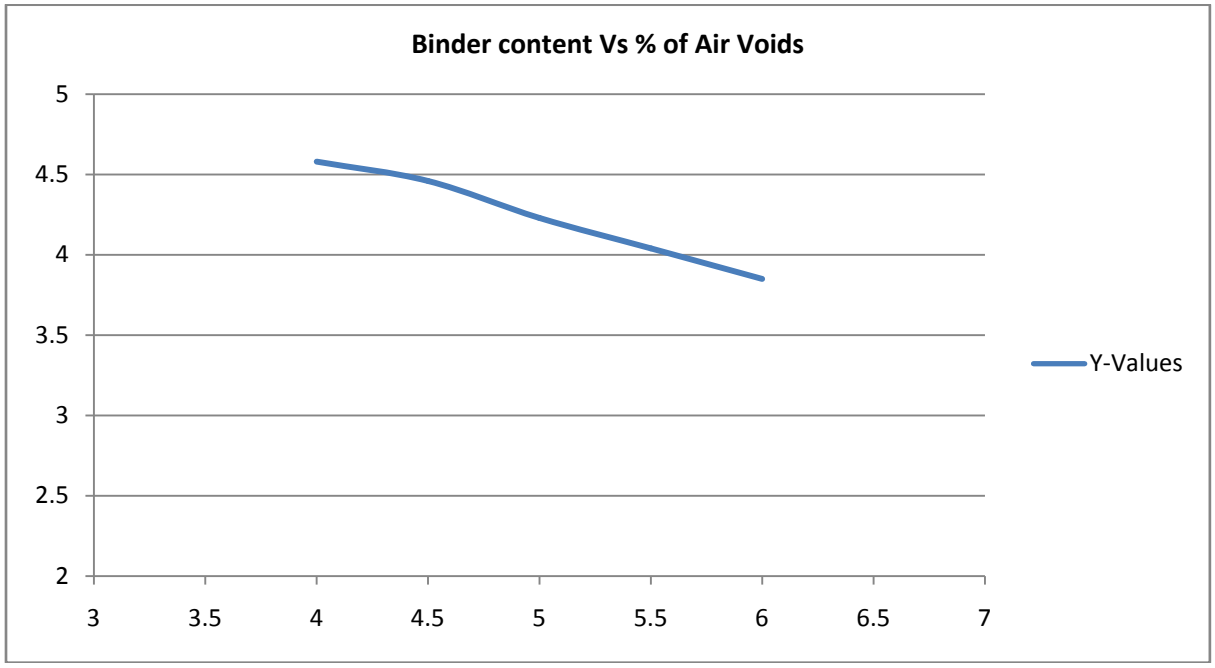

Figure 4: Bitumen % Vs Air voids %.

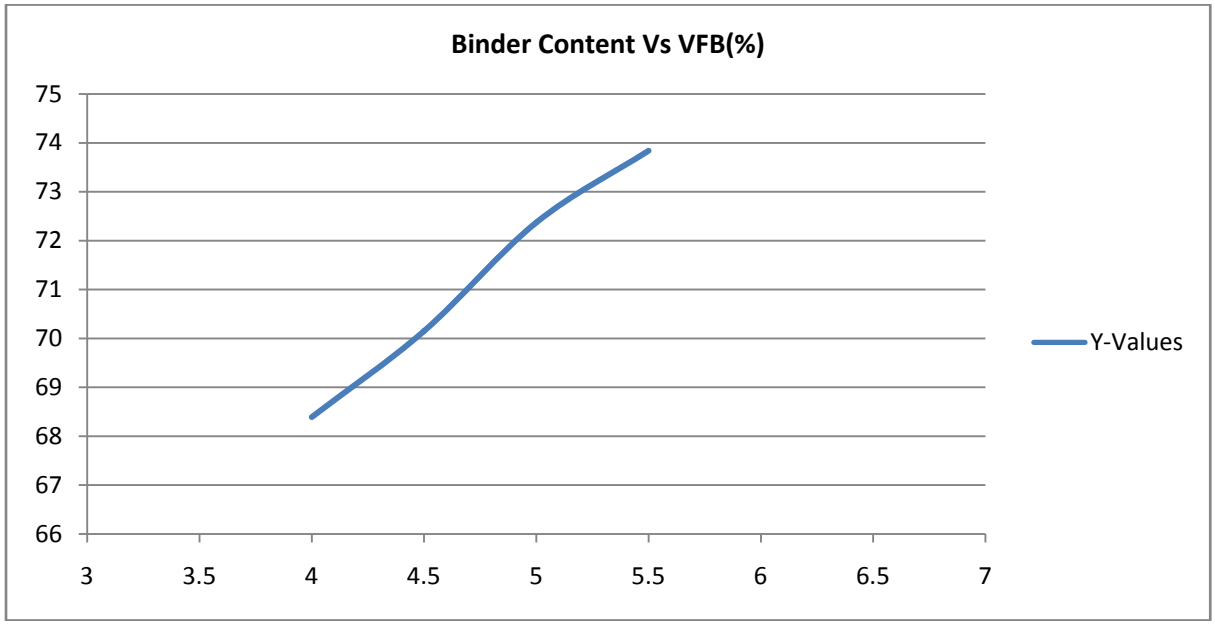

Figure 5: Bitumen % Vs Voids filled with bitumen %(VFB).

IX Conclusion

Based on this study the following conclusions are arrived:

1. Marshal Stability values and flow value of Dense Bituminous Mix (DBM) increase due to addition of LDPE.
2. In LDPE modified bitumen the highest Marshal Stability value is obtained when 8% LDPE is added to the mix.
3. Optimum binder content reduces in case of both LDPE (5%) in comparison to ordinary bituminous mix (5.5%).
4. Marshall's mix design conducted on DBM using LDPE gives results as per MORTH recommendations; indicate the acceptability of the LDPE in Bituminous Concrete mix, since in acceptable range.
5. In present study work is done on dense bituminous concrete for 60/70 grade bitumen modified with addition of LDPE for varying percentage.
6. In future modifiers such as natural rubber, Latex powder, waste polymer, HDPE additives to modify bitumen could be considered. In future, the similar study can be done on Semi Dense Bituminous Mix (SDBM) to get enhanced properties.

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