Comparative Study on Modified Bitumen Using Plastic Waste And Eva Polymer Used In Highway Construction

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Abstract- *Developing Country like India largely depends on flexible pavements made up of bituminous surfaces mainly due to improved traffic intensity of roads, overloading1of commercial vehicles and temperature difference of pavements due to climatic changes leads to formation of several distresses like rutting, shoving, bleeding, cracking and potholing of bituminous surfacing. The disadvantage of these bitumen surfaces is that it becomes soft in summer due to rise in temperature and brittle in winter. The development of a country largely depends on the road network hence in country like India roadway construction is taking place at a very high speed which resulted in large demand of construction material that too eco-friendly and inexpensive. Several Studies have exposed that properties of bitumen and bituminous mixes can be improved with addition of certain additives. The present study is focused on the use of modified bitumen by using plastic waste and Ethylene Vinyl Acetate polymer for road construction. From the experimental investigation the modified bitumen mix of 8% of EVA polymers and 6% of plastic waste was found to be more effective and better stability, density, binding property, and more resistant to water.*

Keywords- Ethylene Vinyl Acetate, Bitumen, Modified Bitumen, Plastic-waste. Stone matrix asphalt(SMA)

I. INTRODUCTION

Conventional bituminous materials have generally performed acceptably in most highway pavement. Though in recent years, several climate condition, increased traffic levels, larger and heavier trucks with new axle designs and high tyre pressures, have seemed to add a severe demands of load and environment1on the highway system. This has resulted in the need to improve the properties of existing asphalt material. In the construction of flexible pavements, bitumen plays a vital role of binding the aggregate together by coating over the aggregate. It also helps to develop the strength of the road. Generally during hot climate season, road surface with base bitumen causes bleeding and in winter leads to the development of crack. Hence this possesses less loads bearing capacity which in turn causes damage due to higher axle load in existing situations.

Various researches have been carried in the effective use of plastic waste in the enhancement of bituminous materials to increase the strength and other properties. Although plastic wastes are friendly they are not eco-friendly as they are non-biodegradable generally, it is generally prepared by the way of land filling or burnings of materials which are dangerous as well as harmful. Also, Usage of plastic wastes in construction of roads helps in numerous ways, like disposal of waste easily, construction of better roads, as well as prevention of pollution and so many. Due to the enhanced binding property of plastic wastes generally in its molten state which has helped in figuring out a method of disposal of plastic wastes safely without polluting environment. When compared to plain bitumen polymer bitumen mixture is healthier binder compound. When this type of bitumen is used for construction of road it can be able to tolerate high temperature as well as higher loads. Reduction in porosity, absorption of moisture content and improved soundness can be achieved by coating of plastic wastes. For flexible pavement construction polymer coated bitumen aggregates combination forms enhanced material as the mix illustrates higher Marshall Stability value as well as suitable Marshall Coefficient. Hence Studies on this subject are going on both at national as well as international level.

Polymers are being progressively used to modify bitumen and to improve the properties of bituminous mixes. The polymer adopted binders are highly suitable for special applications, where traffic is extremely high. However climatic and fraternization temperature play important role in the preparation of polymer modified binder.

II. OBJECTIVES

The main objective of the present investigation is to

- Determine the Marshall Test properties of Bituminous concrete mixes using 60/70 penetration grade bitumen modified using plastic and EVA polymer.

- Comparative study on strength analysis for both the mixes.

- To find a suitable alternative material over conventional materials with cost reduction and improvement in strength and other parameters for flexible pavements.

III. MATERIALS USED

Following are the materials used in the present study

A. Bitumen

- Generally in Indian bitumen used in road construction of flexible pavement is of grade 60/70 or 8/100 penetration grade.
- For present study 60/70 penetration grade bitumen is obtained from karla construction karkalla, Udupi district which was been used in the flexible pavement.

Test where performed based on Indian standard codes. **Table 1** provides the details regarding the physical properties of the bitumen used.

Table 1 – Physical Properties of 60/70 Grade Bitumen

Properties Tested	Test results	Permissible limits
Penetration grade at 25 °c	65	60-70
Softening point (°c)	52	40-55
Ductility (cm)	94	>75
Flash point (°c)	340	>175
Fire point (°c)	355	>175

B. Ethylene Vinyl Acetate polymer (EVA)

For present study EVA Polymer is obtained from Industrial Traders, post office lane, Fathenagar, Hyderabad. EVA polymers are those which contain different proportions of ethylene to vinyl acetate and consist of different molecular weights with different polymer lengths. Typical vinyl acetate levels are 18% and 28% respectively. See Fig. 1

Fig. 1 – EVA Polymer

C. Plastic waste

Fig. 2 – Plastic waste

The3plastic waste has two major categories of plastic, thermoplastic and thermos set plastics. Thermoplastics are 80% approximate and thermos set plastic is 20% approximate of total postconsumer plastic waste generated in India. The waste plastic can easily be mix with the bitumen as the process for road construction using bitumen is heat in the rage of 155/165°c. The plastic waste is collected from Mulki industrial area, Mangalore district. See Fig. 2

D. Aggregates

- The aggregates used in stone matrix Asphalt (SMA) should be highly durable, strong and threatening to resist heavy loads. All aggregates used in the study were collected from the same source (near Nitte). Nominal aggregate size was taken as 13mm.
- Coarse3aggregates: The coarse aggregates were of crushed granite rock retained on 4.75 mm sieve. Table 2 provides tha details of coarse aggregate used.
- Fine aggregates: Fine aggregates passing 4.75mm sieve and retained on 0.075 mm sieve consisted of 100 percent crushed sand resulting from crushing operations of granite rock.

Table 2 - Physical properties of aggregates

Test	Results	MORT &H Specification(2009)
Aggregate Impact Value	22.22%	24% maximum
Los Angeles Abrasion Value	21.6%	25% maximum
Crushing Value	26.43%	30% maximum
Specific Gravity test	2.6	-
Combined Index	25.05%	30% maximum

IV. METHODOLOGY

1. The plastic sample which was procured was cut into smaller pieces.
2. Preliminary tests were performed on aggregate and bitumen.
3. Plastic and EVA polymer was mixed with bitumen and laboratory tests was performed based Marshall Stability test.
4. Study was carried to compare the test results of plastic and EVA polymer.

V. RESULTS AND DISCUSSIONS

Test was performed on Bitumen mixed sample with various proportion of EVA polymers. Specimens when prepared by mixing 2%, 4%, 5% and 6% of polymers. The details of test performed as shown in Table 3.

Table 3 – Physical properties of modified bitumen with EVA polymers

Tests	Bitumen+2% EVA	Bitumen+4% EVA	Bitumen +5% EVA	Bitumen+6% EVA
Penetration at 25°	60	54	45	39
Ductility (cm)	86	75	56	40
Softening point(°c)	59	66	70	78
Flash point(°c)	320	310	280	265
Fire point(°c)	330	318	285	270

Similar to the above, tests were performed on the modified bitumen when mixed with plastic wastes and the effect of ageing on these properties are shown in **Table 4.**

Table 4 – Physical properties of modified bitumen with Plastic

Tests	Bitumen + 2% Plastic waste	Bitumen + 4% Plastic waste	Bitumen + 5% Plastic waste	Bitumen + 6% Plastic waste
Penetration grade at 25°	58	53	50	48
Ductility (cm)	76	60	52	43
Softening point(°c)	56	58	60	63
Flash point(°c)	342	335	320	310
Fire point(°c)	350	345	325	317

A. Test for Penetration value

The penetration test on bitumen is done as per IS 1203-1978. Fig. 3 shows penetration values of conventional and modified binders from 0% to 6% for EVA and Plastic used as binders.

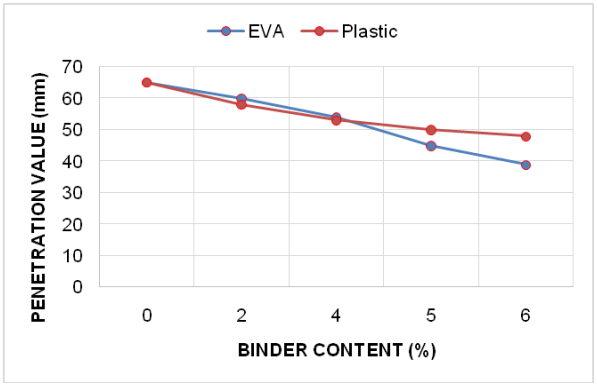

Fig. 3- Penetration value v/s Binder content

B. Ductility Value

The Ductility test on bitumen was conducted based on IS 1208-1978.The Fig. 4 shows ductility values of modified binders and un-modified binders.

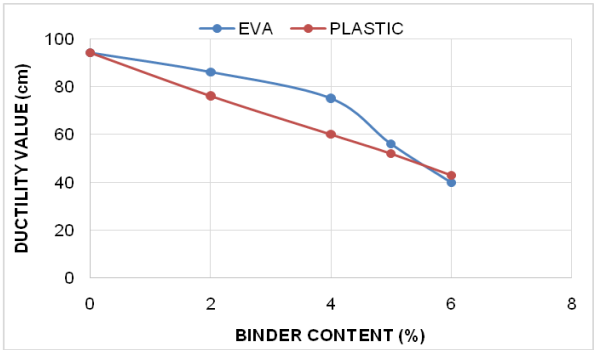

Fig. 4 Ductility value v/s Binder content

C. Softening point

Similar to Penetration and ductility, test for the determination of softening point on bitumen was done as per IS 1205-1978. Figure 5 shows softening point values of modified binders and unmodified binders.

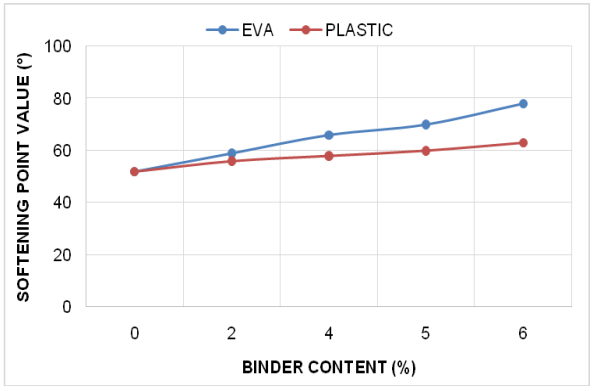

Fig. 5 Softening point value v/s Binder content

D. Flash point

The flash point test on bitumen is done as for IS 1209-1978 for all bituminous bend. Figure 6 shows flash point values of modified binders and unmodified binders.

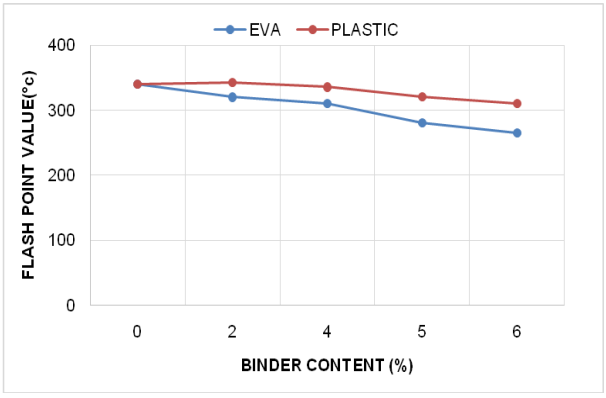

Fig. 6 Flash point v/s Binder content

E. Fire point

The determination of fire point of the given bitumen specimen was performed as per IS 1209-1978. The figure 7 shows fire point values of modified binders and unmodified binders.

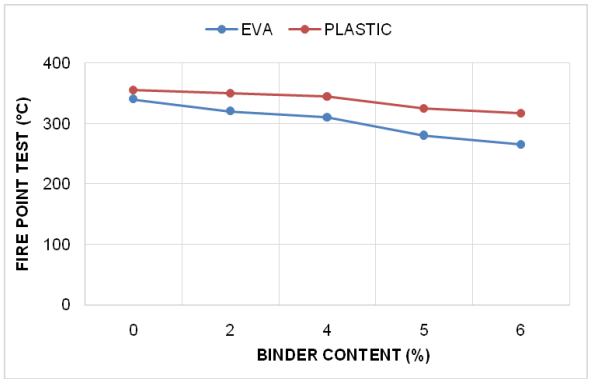

Fig. 7 Fire point value v/s Binder content

MARSHALL MIX DESIGN AND ANALYSIS

In order to withstand heavy traffic loads under adverse climatic conditions suitably designed bituminous mixture is very important which in turn fulfils the requirement of structural as well as pavement surface characteristics. The optimum bitumen content (OBC) for the SMA mixture is determined and it is found to be 6.5 % by the weight of total mix. See fig. 8

Fig. 8 – Marshall Stability test

A. EVA polymer stabilized mixtures

Test results of volumetric and mechanical properties of SMA mixtures using different EVA polymer proportion are tabulated in given below.

Table 5 - Variation of Marshall Stability value with different % of EVA polymer

Additive	%	Height in (mm)	Flow value (mm)	Load in (kN)	Correction Factor	Corrected load in (kN)
EVA	2	68.53	4	10.1	0.89	9.02
	4	68.33	3.7	11.2	0.89	9.98
	6	71.6	3.6	12.5	0.86	10.76
	8	67.83	3.05	12.3	0.90	11.07
	10	69.66	2.65	10.7	0.86	9.26

Table 6 - Vv, VMA and VFA with different % of EVA polymer

Additive	%	G_t	G_m	V_v	V_b	VMA	VFB
EVA	2	2.39	2.30	3.96	15.13	19.14	79.14
	4	2.39	2.32	3.80	15.26	18.39	79.95
	6	2.39	2.29	3.46	15.09	19.37	81.42
	8	2.39	2.29	2.99	15.06	19.56	83.69
	10	2.39	2.31	2.72	15.19	18.79	86.57

Note: G_t= theoretical specific gravity; G_m= Bulk Density, V_v volume of air voids, V_b=volume of bitumen; VMA= voids in mineral aggregate; voids filled with bitumen

B. Plastic waste stabilized mixtures

Test for the determination of the volumetric properties and mechanical properties of SMA mixtures where conducted by using different Plastic waste. The results are tabulated in **Table 7** given below.

Table 7 -Variation of Marshall Stability value with different % of Plastic waste.

Additive	%	Height in (mm)	Flow value (mm)	Load in (kN)	Correction Factor	Corrected load in (kN)
Plastic waste	2	69.33	3.87	9.20	0.865	7.95
	4	67.2	3.65	10.20	0.915	9.35
	6	67.9	3.36	11.10	0.90	9.99
	8	69.33	3.05	10.80	0.865	9.34

The above results indicate that the mixture using plastic waste will result in higher performance than using the controlled mixture. Variation of Marshall Stability and flow value with different Plastic waste contents are shown in Table & and Table 8.

Table 8 -Vv, VMA and VFA with different % of plastic waste

Additive	%	G_t	G_m	V_v	V_b	VMA	VFB
Plastic waste	2	2.39	2.29	4	15.1	19.08	77.5
	4	2.39	2.32	3.19	15.1	18.35	82.7
	6	2.39	2.34	2.44	15.2	17.65	86.5
	8	2.39	2.85	1.72	15.4	17.19	90

VI. CONCLUSION

From the above experimental investigation the following conclusion can be summarized.

- The addition of EVA and Plastic waste modified binder gave a lower Penetration value as compared to normal bitumen.
- The values of Softening and fire point was higher when EVA and Plastic waste was mixed.
  The values of ductility was found to reduced by the addition of EVA and plastic waste.
- From the experiential study it was observed that EVA polymer stabilized mixtures give maximum stability at 8 % of EVA content.
- Comparing different EVA stabilized mixtures; it is evident that the mixtures with EVA content have the highest stability at 11.07 kN.
- It also observed that the plastic stabilized mixtures give maximum stability at 6% of Plastic content.
- In comparison with different plastic stabilized mixtures, it is observed that mixtures with Plastic content have highest stability at 9.99 kN.

VII. ACKNOWLEDGEMENT

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