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A Study on Enhancement of Bitumen Properties

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Abstract— Traffic volume and percentage of heavy vehicle have increased in last few decades, so it is in demand from pavement engineers to provide strong and durable pavements. There is a need to explore new and innovative material for extending the life of pavements to increase the predicted design life of the pavement. For that purpose we can use plastic waste in molten state for bituminous mix. Plastics are non-biodegradable, of course these are user friendly but not ecofriendly material and generally it is disposed by way of land filling which is hazardous for ground water table and or by incineration of materials which are hazardous for environment and mankind. The better way of disposal of waste plastic may be using it in molten state. In this paper behavior of bitumen mix with the use of plastic waste for construction purpose of roads and flexible pavements has reviewed. Generally bitumen is used as binder,such bitumen modified with waste plastic pieces and bitumen mix is prepared, which can be used for flexible pavement. This modified bitumen mix enhanced the various properties of bitumen and filler properties which are discussed in the paper.

Key words: plastic waste, stability, durability, bitumen mix, filler

I. INTRODUCTION

Plastics can stay unchanged for as long as 4500 years on earth with increase in the globalPopulation and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively.The experimentation at several institutes indicated that the waste plastic, whenadded to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with thebinder is found to give higher strength, higher resistance to water and better performance over a period of time. Wasteplastic such as carry bags, disposable cups and laminated pouches like chips, pan masala, aluminum foil and packagingmaterial used for biscuits, chocolates, milk and grocery items can be used for surfacing roads.

II. LITERATURE REVIEW

A. Present Scenario:

Bituminous binders are widely used in road paving and their visco-elastic properties are dependent on their chemical composition. Now-a-days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a situation to think about some alternative ways for the improvement of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects. Bitumen can also be modified by adding different types of additives to achieve the present requirement. One of these additives is the polymers.

B. Waste Plastic: The Problem:

Today availability of plastic waste is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing. Nearly 50% of total plastic are consumed for packing. Once used, plastic packing materials are thrown outside and they remain as waste. Plastic wastes are durable and non-biodegradable. The improper disposal of plastic may cause cancer, reproductive problems in humans and animals, genital abnormalities and much more. These plastic wastes get mixed with water, disintegrate, and take the forms of small pallets which cause the death of fishes and other aquatic life who mistake them as food material. Sometimes they are either land filled or incinerated. Plastic wastes get mixed with the municipal solid waste or thrown over a land area. All the above processes are not eco- friendly as they pollute the land, air and water. Under these circumstances, an alternative use of these plastic wastes is required. So any method that can use this plastic waste for purpose of construction is always welcomed.

III. OBJECTIVE OF THE WORK

The main objective of this work is to evaluate the influence of the waste plastic on the mechanical properties of the bituminous concrete mixes with a view of finding an alternate disposal and usage of this waste plastic.

A. Scope of Study:

To fulfill the above objective identified scope of study is as follows:

- To identify the various problems faced by bituminous pavements.
- To study the environmental and health impact of plastic waste and identify the plastic types that can be used for preparation of bituminous mix.
- To prepare the bituminous mix with and without using the waste plastic (LDPE & HDPE) in various proportions and perform the marshal's stability test.
- To compare the result of samples without plastic with that of the samples using LDPE & HDPE and evaluate the effect of waste plastic on properties of bituminous concrete mixes and its contribution in the reduction of the environmental impact.

IV. CONSTITUENTS OF A MIX

Bituminous mix consists of a mixture of aggregates

continuously graded from maximum size, typically less than 25 mm, through the fine filler that is smaller than 0.075mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical.

The basic materials used are as follows:

- Aggregates
- Bituminous Binder
- Plastic waste

V. Preparation of Marshall Samples

The mixes were prepared according to the Marshall procedure specified in ASTM D1559.For Bituminous Concrete mixes the coarse aggregates, fine aggregates and filler were mixed with bitumen and polyethylene according to the adopted standard gradation. First a comparative study was done on for BC for different proportions of bitumen at different percentage composition of plastic. The mixing of ingredients was done as per the following procedure-

- Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in an iron pan and kept in an oven at temperature 160 for 1 hour. Preheating is required because the aggregates and bitumen are to be mixed in heated state.
- The required amount of shredded polythene (LDPE or HDPE) was weighed and kept in a separate container.
- The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature. For
  1) Dry Mix- Polyethylene was added to the aggregate and was mixed for 2 minutes.
  2) Wet Mix- Polyethylene was added to the hot bitumen till it stirred till it achieves consistency.
- Now bitumen was added to this mix and the whole mix was stirred uniformly and homogenously. This was continued for 15-20 minutes till they were properly mixed which was evident from the uniform color throughout the mix.
- Then the mix was transferred to a casting mould. 75 no. of blows were given per each side of the sample so subtotal of 150 no. of blows was given per sample. Then each sample was marked and kept separately.

VI. Experimental Observations

1) Marshall Properties of bitumen with variable composition of LDPE

Bitumen Content	LDPE Content	Flow Value	Stability	Water Absorption %	% Air Voids
5	3	5.7	2100	0.882	8.22
5.5	3	5.8	1785	0.67	7.64
5	5	5.79	1738	1.2	8.6
5.5	5	7.43	1828	0.7	8.11
5	8	6.53	2055	1.02	8.3
5.5	8	7.82	2025	0.82	9.08
5	0	6.71	1650	0.99	10.37
5.5	0	8.18	1522	0.88	9.91

Table 1: Marshall Properties of bitumen with Variable

2) Properties of bitumen with variable composition of HDPE

Bitumen %	HDPE Content %	Flow Value	Stability	Water Absorption	% Air Voids
5	5	8.226	3041	0.76	4.97
5.5	5	6.14	3205	0.72	5
5	8	7.89	3581	0.7	7.62
5.5	8	5.42	3241	0.68	6.1
5	12	9.26	3776	0.65	10.19
5.5	12	7.89	3479	0.63	11.49
5	0	6.71	1650	0.99	10.37
5.5	0	5.2	1522	0.88	9.91

Table 2: Marshall Properties of bitumen with Variable composition of HDPE

3) Test results of Ductility and Penetration

Test	LDPE Content	Test Results	Standard Results
Ductility	0%	77.4	75
	3%	55.5	17
	5%	46.2	11
Penetration	0%	69.7	50-80
	3%	39	30-50
	5%	31.3	20-30

Table 3: Test results of Ductility and Penetration tests with variable LDPE composition

4) Comparative Analysis Result for different properties of Marshall Mix

	Plastic	% Content	Bitumen	Stability	Flow Value	% Water Absorption	% Air Void
Plastic as a Binder	LDPE	3%	5.0%	2100	5.7	0.882	8.22
			5.5%	1785	5.8	0.67	7.64
		5%	5.0%	1738	5.79	1.2	8.6
			5.5%	1828	7.43	0.7	8.11
Plastic as A filler	LDPE	8%	5.0%	2055	6.53	1.02	8.3
			5.5%	2025	7.82	0.82	9.08
	HDPE	5%	5.0%	3041	8.226	0.76	4.97
			5.5%	3205	6.14	0.72	5
		8%	5.0%	3581	7.89	0.7	7.62
			5.5%	3241	5.42	0.68	6.1
		12%	5.0%	3776	9.26	0.65	10.19
			5.5%	3479	7.89	0.63	11.49
Normal Mix		0%	5.0%	1650	6.71	0.99	10.37
			5.5%	1522	8.18	0.88	9.91

Table 4: Comparative Analysis Results with Plastic as Binder and Filler

A. *Marshall Stability:*

It is observed from graphs that with increase in bitumen concentration the Marshall stability value increases up to certain bitumen content and there after it decreases. That particular bitumen content is called as optimum binder content (OBC). In present study OBC for conventional BC mix was found at 5.5%.

From the graphs it can be observed that with addition of polyethylene stability value also increases up to certain limits and further addition decreases the stability. This may be due to excess amount of polyethylene which is not able to mix in asphalt properly.

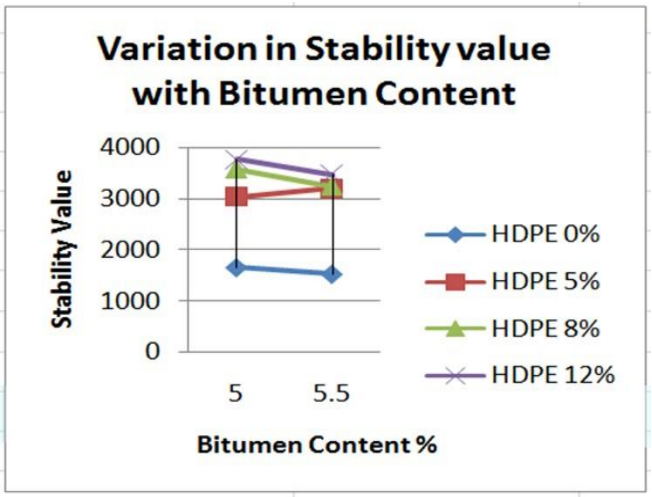

Fig. 1: Variation In stability with bitumen content and HDPE

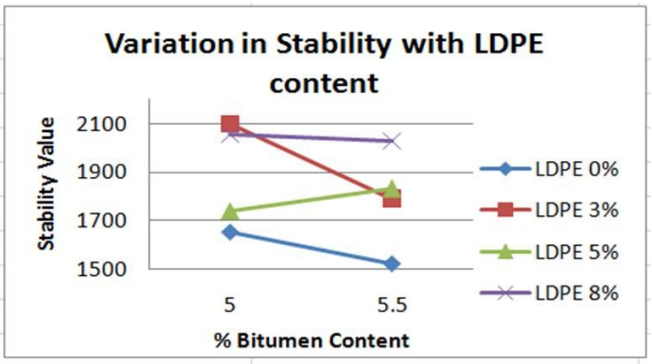

Fig. 2: Variation In stability with LDPE content

B. Flow Value:

It is observed from graphs that with increase in binder content flow value increases but by addition of polyethylene as a binder flow value decreases than that of conventional mixes and as a filler increases.

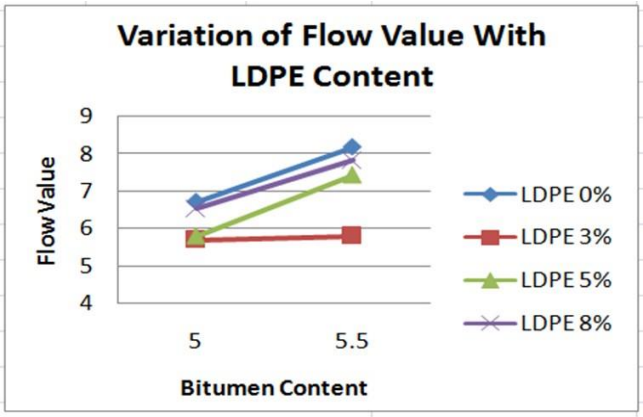

Fig. 3: Variation of Flow value with LDPE

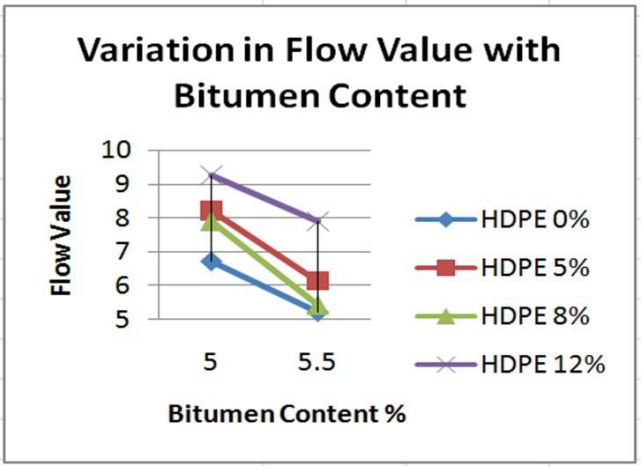

Fig. 4: Variation in flow value with HDPE

C. Air void (VA):

It is observed that with increase in binder content air void decreases. But with addition of polyethylene to mix the air void is increasing than that of conventional mixes.

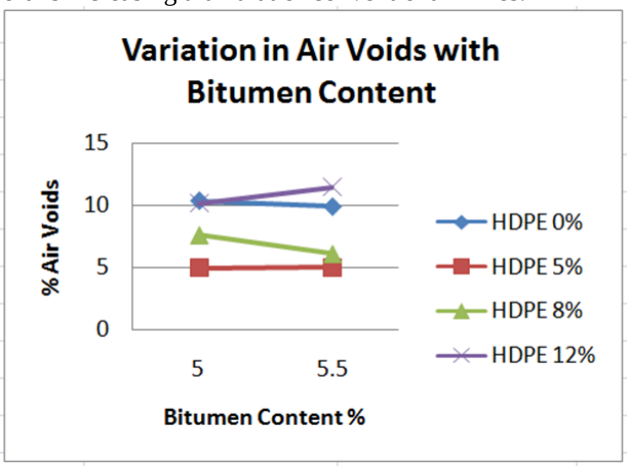

Fig. 5: Variation in Air Voids with HDPE

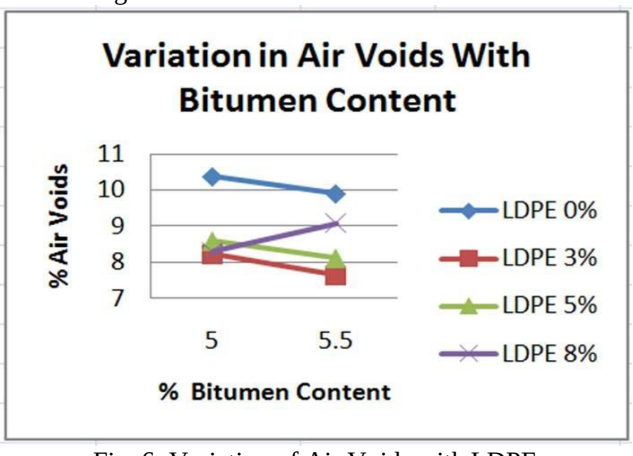

Fig. 6: Variation of Air Voids with LDPE

D. Water Absorption (WA):

As the percentage Air voids decreased so the water absorption values have increased to some extent due to the formation of lumps or improper mixing.

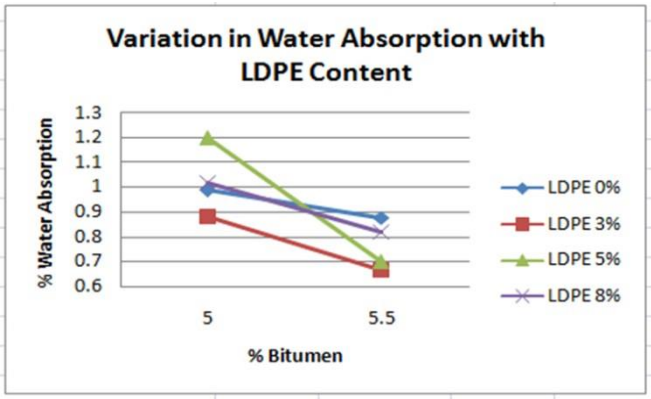

Fig. 7: Variation of Water Absorption with LDPE

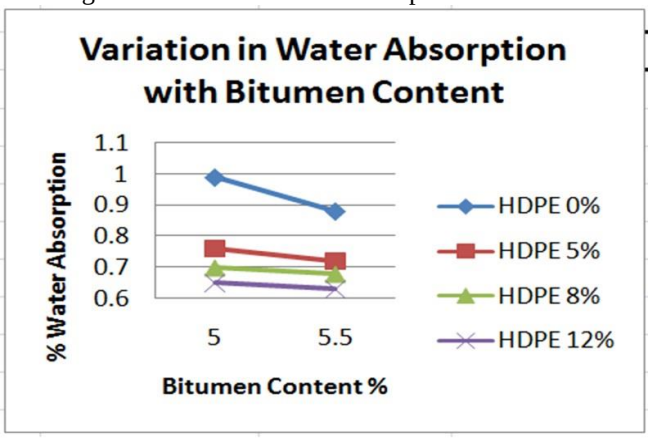

Fig. 8: Variation in Water Absorption with HDPE

VII. Discussion

A. *Material Behaviour As A Binder:*

Ductility- Bitumen as a binder has high ductility value but due to the brittle behaviour of plastic after burning ductility is reduced to a greater extent. So Ductility here depends more on the consistency of the mix and sometimes sudden failure takes place.

Penetration- Penetration defines the consistency of the mix at a given temp so higher the percentage of plastic mix lesser be the penetration. Due to formation of thin films in between these layers penetration is lesser

B. *Material Behaviour as a Filler:*

- With increase in plastic content as a filler voids are reduced to a greater extent due to coating of plastics over the aggregates in the transition zone.
- As the air voids are reduced lesser will be the absorption of water inside therefore lesser stripping of bitumen and hence better durability.
- With proper filling of voids as filler n proper coating of aggregates as binder better Marshall Mix properties are achieved higher stability and lesser flow values.
- Flow value of the Marshall Mix has increased with plastic as filler and as a binder it is reduced.

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