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Use of plastic waste Materials in bituminous mix

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Abstract

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. 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.in this reseach study The regular bitumen (60/70 GRADE) and modified bitumen samples were tested in the laboratory. The sample's individual qualities were determined (penetration, softening point, ductility, flash and fire, and specific gravity). Characterization of standard bituminous mix (60/70 GRADE) for dense bituminous mix (DBC) was carried out using the Marshal Mix design, and a comparison of traditional bitumen mix qualities with modified bitumen was conducted.

Keywords- bituminous mix, dense bituminous mix, Marshal Mix design, polymers, softening point, specific gravity.

I. INTRODUCTION

Bitumen is used to bind the aggregate together in the creation of flexible pavements by covering the material. It also aids in the strengthening of the road. However, it has a low water resistance. There are anti-stripping compounds in use.

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.

Modifying the rheological qualities of bitumen by combining it with organic synthetic polymers like rubber and

plastics is a typical way to increase its quality. On a national and international basis, research is being conducted on this topic.

Plastic solid waste generated by both domestic and industrial is also suitable for other application such as flexible pavements. Waste plastic includes polyethylene, polypropylene and polystyrene softening between 100 deg. C to 150 deg. c. Duringsoftening, there is no harmful or toxic gases produced.

But it is easily boned with concrete gravel and form the film over the concrete pieces providing good water resistance. There is good scope of using municipal plastic solid waste on road to prevent the degradation of roads. Plastic is a versatile material but it become a serious problem after its use.

Most of the plastic materials are plastic carry bags, plastic cups, films and foams made from polyethylene, polypropylene and polystyrene. The municipal plastic waste is either incinerated or used for land filling. But these techniques are not an effective way to utilize the plastic waste properly.

Utilizing the plastic waste in the asphalt pavement application is a right approach and it will help to dispose the waste by eco-friendly way.

Use of High density polyethylene (PLASTIC SCRAP AND BAKELITE), in bitumen and bitumen mixes for DBC (Dens Bituminous Concrete). The addition of polymers to bitumen can result in considerable changes in the mechanical properties of the bitumen.. To use a non-biodegradable ingredient that would otherwise be harmful to the environment in highway bituminous mixes, therefore significantly boosting the stability, strength, fatigue life, and other desirable attributes of the bituminous concrete mix, even in the face of severe water-logging.. As a result, the life of the pavement surfacing course employing modified bitumen is predicted to be significantly longer than that of standard bitumen.

Increasing axle loads, weather variability, and traffic development have prompted the paving industry to examine the demands placed on bitumen pavement construction. In this regard, physical modification of base bitumen began in the 1980s with the inclusion of certain additives such as polymers, plastics, and other materials to improve the mechanical behavior of bitumen. Chemical modifications, such as polyethylene and polyphosphoric acid, were also tried. Modified bitumen can be used for a variety of reasons. It can be used to target a specific bitumen improvement, such as persistent deformation (rutting) or low-temperature cracking.

The following are some of the advantages of binder modification:

- Improved consistency
- Reduced temperature susceptibility
- Improved stiffness and cohesion
- Improved flexibility, resilience and toughness
- Improved binder aggregate adhesion
- Improved resistance to in-service aging

A study of the thermal behavior of polymers such as polyethylene, polypropylene, and polystyrene demonstrates that they soften easily without releasing gas between 130 and 1700 degrees Celsius, which has been scientifically proven. They disintegrate at roughly 3500°C, releasing gases such as methane and ethane, and they burn at temperatures beyond 7000°C, releasing gases such as CO and CO2

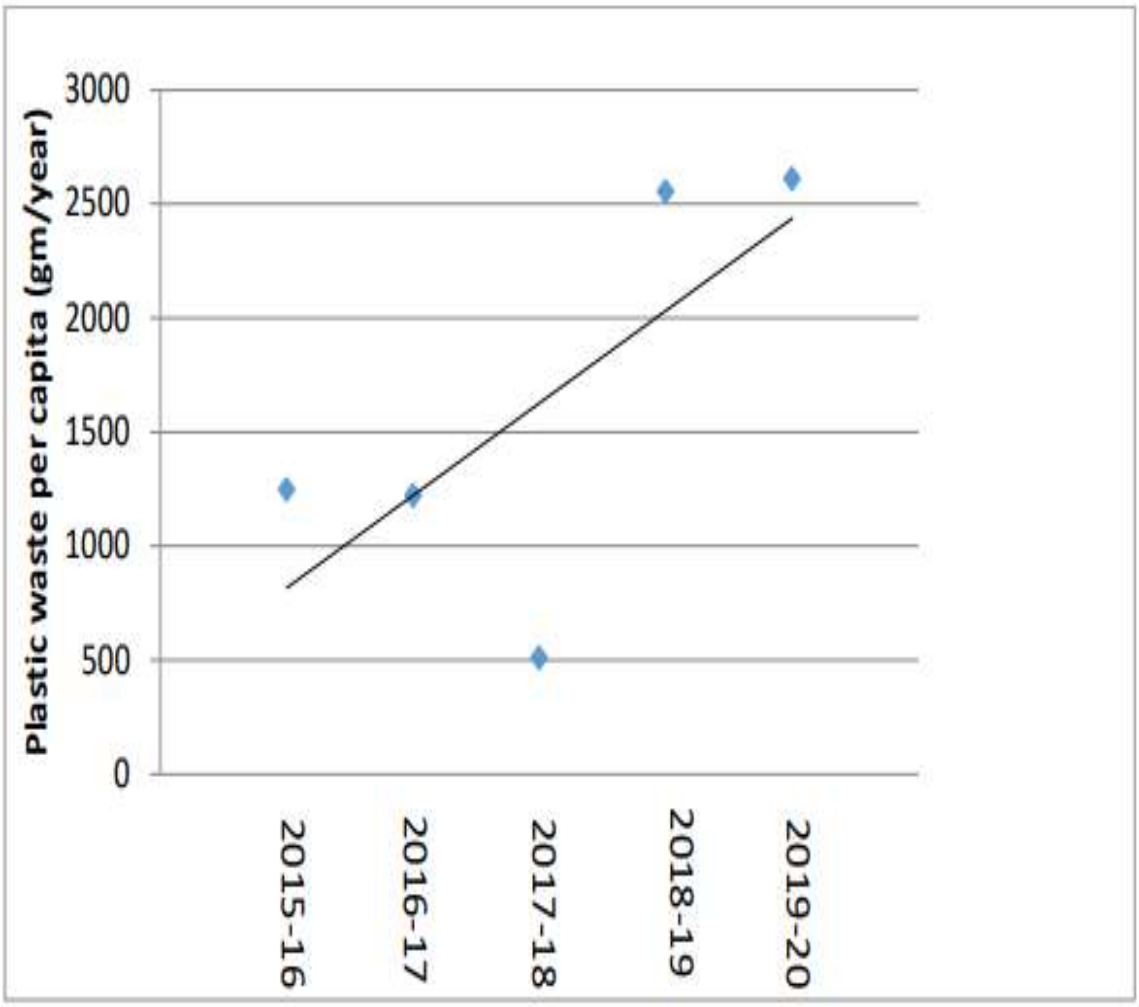

Fig. 1. Per capita Plastic waste generation in India

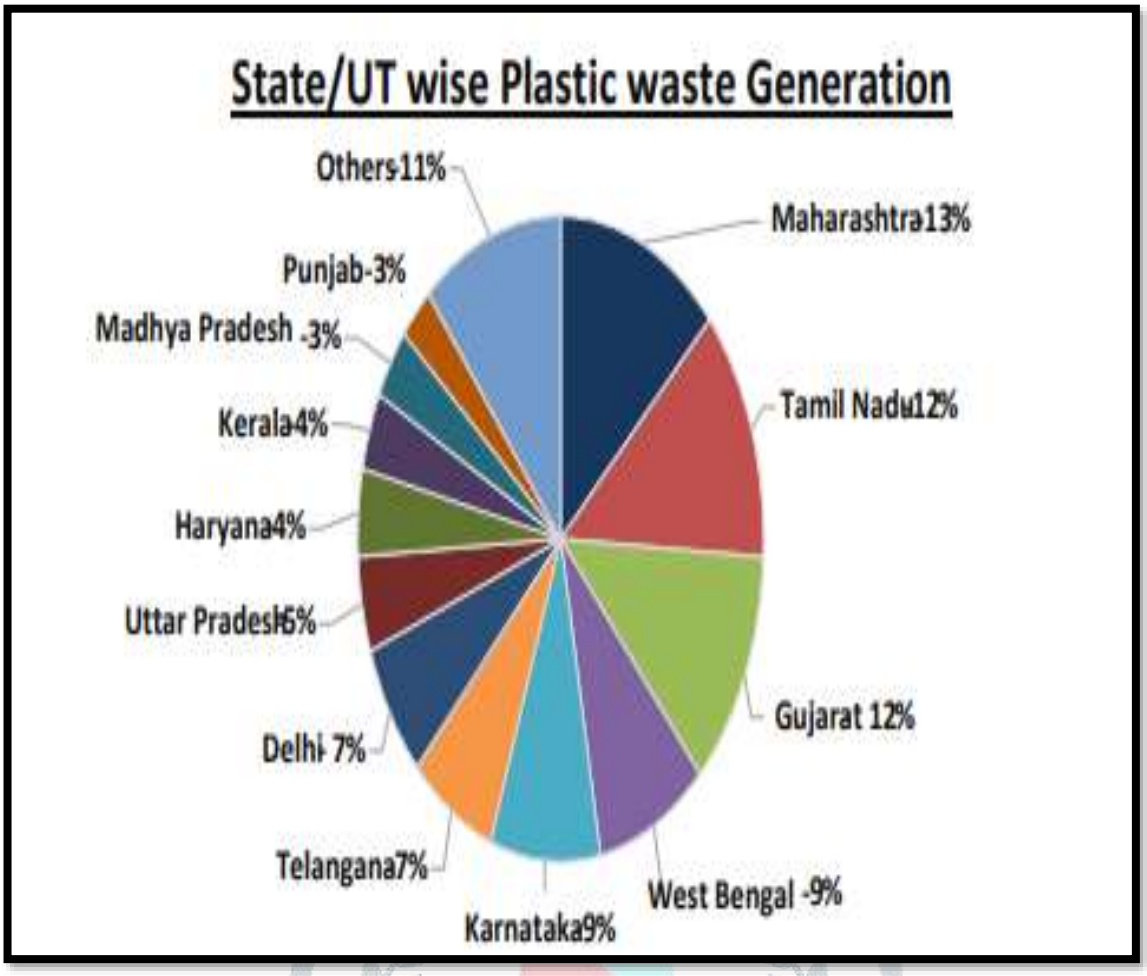

Fig. 2. State/UT wise Plastic waste generation.

II. MATERIAL USED

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
- fiber waste plastic scrap Bakelite
- Bituminous Binder

III. METHODOLOGY

There are two processes for combining modifier with bitumen to get sample - wet process and dry process. A short account of two processes is given as follows.

Wet Process: In wet process, modifiers are added to the molten bitumen. The aggregate is then added to the molten mix of bitumen and modifier(s).

Dry process: In dry process, modifiers are added to the hot aggregate (Temp. 170°C). Thisaggregate mix is then added to the molten ordinary bitumen (Temp. 155- 163°C). Temperature maintenance is essential for proper blending.

The optimum binder content of the bituminous mixes, marshall stability and flow values and marshall properties of the mix can be determined by performing Marshall Stability Test. Aggregate grading was done within MORTH specifications for 3 type of proportions (2%, 4% and 6% of shredded waste bakelite) in bituminous mixes. Each sample is tested as per specifications and the observations are made.

According to MORTH specification, aggregate for DBC is prepared using 40% 10 mm, 30% 6 mm, 28% dust and 2% cement. Specific gravity and density of 10mm aggregate, 6 mm aggregate, dust and cement is determined, which will be used later in result analysis. This aggregate mix will be common for all types of samples.

Table 1 Cases Considered

Sample ID	% of waste Plastic bakelite	% of bitumen
S 0	0%	5%
S2	2%	5%
S4	4%	5%
S6	6%	5%

Table 2 Amounts of raw materials

Plastic scrap and Bakelite %	Wt. Of plastic scrapand Bakelite	wt of aggregate
	gm	gm
0	0	1140
2	22.8	1117.2
4	45.6	1094.4
4	45.6	1094.4
4	45.6	1094.4
6	68.4	1071.6

Fig. 3. Sample of Bituminous Mix

IV. RESULTS

A laboratory test was conducted to determine the physical parameters of bitumen for dense bituminous mix, and the findings are listed in the table below

Physical properties of 60/70Grade bitumen:

Different tests were carried out to determine the physical qualities of conventional bitumen,and the findings are listed in the table below.

Table 3: Physical properties of 60/70Grade bitumen

S.No.	Properties	Test Results
1	Penetration at 25°C/100gm/5Sec,mm	65
2	Softening point, °C	60
3	Ductility, cm	98
4	Specific gravity, at27°C	1.001
5	Flash point, °C	318
6.	Fire point, °C	340

Table 4 Properties Of DBM With ordinary Bitumen and Varying Percentage Of Bitumen Binder

	Bitumen %	S.No		Marshal stability (Kg)	Flow value (MM)	Bulk Density	Air Voids %	VMA	VFB %
		Air	Water						
1	4.5	1190	683	1075	2.41	2.347	5.38	14.29	62.37
2	5.0	1196	692	1120	2.55	2.373	4.79	15.05	68.19
3	5.5	1184	688	1186	2.67	2.387	3.81	15.14	74.84
4	6.0	1186	681	1138	2.83	2.348	3.34	15.25	78.11

Results of DBM with fiber waste plastic scrapmaterial + Bakelite

Table No. 5 Physical properties of Modified Bitumen

S.No.	Properties	Test Results		
		2%	4%	6%
1	Penetration at 25°C/100gm/5Sec, mm	50	47	45
2	Softening point in °C	83	84	87
3	Ductility, in cm	67	65	61
4	Specific gravity, at 27°C	1.001	1.002	1.002
5	Flash point, in °C	320	307	291

Table 6: Properties of DBM with Fiber Waste Plastic Scrap Material + Bakelite Modified Bitumen When Using Optimum Binder Content (5.5%)

S.No	fiber waste plastic scrap material with Bakelite %	Weight of sample (gm)		Marshal stability (Kg)	Flow value (MM)	Bulk Density	Air Voids %	VMA	VFB %
		Air	Water						
1	2%	1117.2	689	1297	2.45	2.367	3.97	13.38	70.34
2	4%	1094.4	685	1345	2.57	2.376	3.85	14.60	73.63
3	6%	1071.6	683	1445	2.63	2.378	3.79	15.26	75.17

Table 7: Properties Of DBM With 4% Fiber Waste Plastic ScrapMaterial + 4% Bakelite 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	15.37	73.37
4	5.5	1195	694	1412	2.86	2.385	4.04	15.46	75.84

V. CONCLUSION

After comparing the values of different parameters with acceptance criteria it can be concluded that Marshal Stability values and flow value of bituminous mix are increased due to addition of Plastic Scrap and Bakelite. In Plastic Scrap and Bakelite modified bitumen the higher marshal stability value is obtained when 4% fiber waste plastic scrap material with 4% Bakelite is added to the mix.

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