Use of Plastic Waste As A Binding Material In Road Construction

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Abstract - The use of plastic and related materials is increasing exponentially due to tremendous growth in population, urbanization and changed life style leads to widespread littering of plastic on the landscape. Disposal of waste plastic is a serious problem globally due to their non-biodegradability and hazardous to human health, since these are not disposed scientifically and thus, creates ground and water pollution. If this curse to mankind in the form of waste plastic is used as a boon for mankind by using it as additives in road construction, it will have proved to be a best solution over worst road condition. In this paper study is done to improve workability of flexible road pavement, an attempt is made to use VG 30 grade bitumen with polyethylene form the plastic west having benefits of reducing time and cost of testing without sacrificing its quality. Waste plastic road can improve road strength. This modified bitumen mix and aggregates show better binding property, stability, density and more resistant to water thus increasing durability of roads with increased resistance to wear and tear of road. Use of plastic waste also reduced the cost of construction. Modified bituminous mix and aggregate suitable doses is prepared and tested to determine key properties of Marshall Mix design as per the provisions of codal practice.

Key Words – VG (Viscosity grade), Polyethene, Modified Bituminous Binders, Plastic Road.

1. INTRODUCTION

The threat of disposal of plastic will not solve until the practical steps are not initiated at the ground level. It is possible to improve the performance of bituminous mixed used in the surface course of roads. Studies reported in the use of recycled plastic, mainly polyethylene, in the manufacture of blend indicated reduced permanent deformation in the form of rutting and reduced. Looking forward the scenario of present life style a complete ban on the use of plastic can't be put. Although the waste plastic taking the face of devil for the present and future generation, we can't avoid use of plastic but we can reuse it.

2. OBJECTIVES

The main objective is to evaluate the engineering properties of modified bituminous mix by adding the plastic in doses of 1% to 9% and analyze the performances of modified bituminous mix with aggregate in doses of 5% to 6% samples through Marshall Test.

3. MATERIALS USED

The materials used for the preparation of mix are:-

A. Aggregate

Aggregate was obtained from a local quarry, the coarse aggregates of varying size of aggregates from 20 mm and retained on a 2.36 mm sieve while fine aggregate shall consist 100% of fine crushed sand passing the 2.36 mm sieve and retained on 0.075 mm sieve and the physical properties were tested in the laboratory and are given in Table 1

B. *Bitumen*

VG 30 bitumen was obtained from Cochin Refineries Ltd. The physical properties of this bitumen are shown in Table 2.

Table 1 Physical properties of Aggregates

Sr.No.	Property	Test	Test Result	Requirement	IS Code
1	Toughness	Aggregate Impact value	20.712%	Max. 24%	IS: 2386 (Part IV) – 1963
2	Particle shape	Flakiness and elongation Index (combined)	29.621%	Max. 35%	IS: 2386 (Part I) – 1963
3	Specific Gravity	Specific Gravity	2.681	2.5 -3.0	IS: 2386 (Part III) – 1963
4	Porosity	Water absorption Test	20 mm Agg.=0.394% 6 mm Agg.= 0.607 %	0.1%-2%	IS: 2386 (Part III) – 1963
5	Hardness	Los Angeles Abrasion Test	24.361%	Max. 30%	IS: 2386 (Part IV) – 1963
6	Strength	Aggregate Crushing Test	28.51%	Max. 30%	IS: 2386 (Part IV) – 1963

Table 2 Physical properties of VG 30 grade Bitumen

Sr. No.	Type of test Test Method	Test Result	Requirement	IS Code
1	Penetration Test at 25° C, 0.1 mm, 5 sec	63	50-70	IS: 1203-1978
2	Ductility test (cm)	93	Min 40	IS: 1208-1978
3	Softening Point test, °C	50	Min. 47	IS: 1205-1978
4	Specific gravity test	1.01	Min 0.99	IS: 1202-1978
5	Viscosity test at 60° C, poise	2689	Min. 2400	IS: 1206-1978

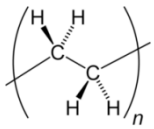
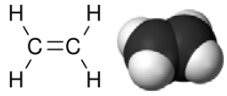
C. Plastic.

The waste plastic used was polythene carry bags (less than 60 microns) collected from the nearby locality. The plastic pieces were sieved through 4.75 mm sieve and retaining at 2.36 mm sieve was collected. The properties of plastics are shown in Table 3

D. Filler.

Stone dust was used as the filler material. The specific gravity of stone dust is 2.72. 5% Stone dust was used by weight

Table 3 Properties of Plastic

IUPAC name	Polyethene or poly(methylene)
Other name	Polyethene
Chemical formula	
Density	0.91–0.96 g/cm^3
Melting point	115–135 °C (239–275 °F; 388–408 K)[1] (239–275 °F)
Magnetic susceptibility (χ)	9.67×10−6 (HDPE, SI, 22° C)
Monomer	 Ethylene (ethene)

4. EXPERIMENTAL PROGRAMME

A. Preparation of Modified Bituminous Binders

The collected Plastic waste was cut into small pieces as far as possible. It is clean by washing. The plastic pieces were sieved through 4.75 mm. sieve and retaining at 2.36 mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160° c-170° c which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170° c. The mixture was stirred manually for about half an hour. In that time period temperature was kept constant about 160-170° c. Plastic-bitumen mixtures of different compositions were prepared for experimental procedures. The percentage of modifier varied from 1% to 9%.

B Test results and discussions

Different percentages of modifier (waste plastic fibers) added to VG 30 grades of bitumen affected the physical properties of the binder in terms of penetration, softening point, ductility and viscosity which is presented in Table 4.

1. Penetration Test Results

The Penetration values are decreasing significantly when VG 30 grade bitumen are mixed with the modifier and this variation is much more when firstly plastic is added in bitumen. And after this when continuously increases plastic modifier by the 1% of weight, small decrement is occur in the penetration value, and after 8% this decrement is more than the previous value of penetration. Thus there is a significant decrease in penetration values for modified blends, indication the improvement in their temperature susceptibility resistant characteristics.

Table 4 Properties of modified bitumen

Bituminous Binder+%Modifier	Penetration	Ductility	Softening Point	Viscosity at 60° C, poise
VG 30 Bitumen	63.00	93.00	50.00	2689
VG 30+1%	56.231	92.522	50.654	4430
VG 30+2%	55.941	91.804	51.155	6850
VG 30+3%	55.253	91.102	51.822	7100
VG 30+4%	54.614	90.451	52.355	7900
VG 30+5%	54.121	89.784	52.92	7200
VG 30+6%	53.665	88.240	53.524	6450
VG 30+7%	52.001	88.355	54.00	6725
VG 30+8%	51.851	87.661	54.821	7290
VG 30+9%	50.555	86.256	56.757	7500

2. Softening point test results

The softening point is increase when plastic percentage is increases modifiers bitumen and this is due to the bitumen becomes increasingly viscous. Softening point of VG 30 grade bitumen, increase to more than 55^0 c by addition of 9 percent fibers. Therefore 8 percent should be the upper limit for VG 30 bitumen. The results show that lower percentage of plastic fibers can be used in road construction satisfactorily.

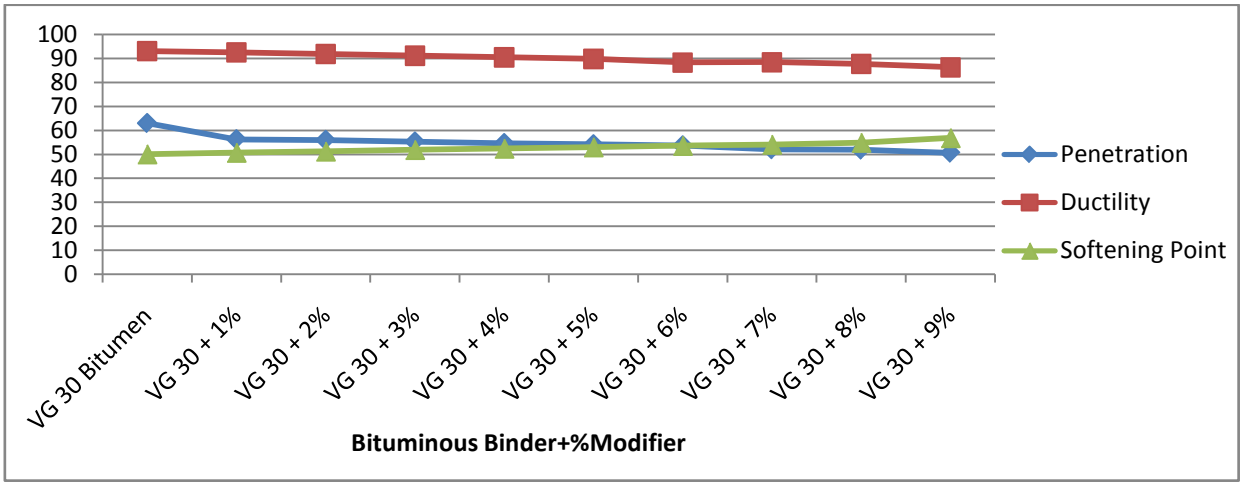
3. Ductility test results

The binders possessing high ductility have good cementing qualities in the road surface and adhere well to aggregates. It may be seen that he ductility values for VG 30 bitumen modified with 9 percent modifiers are low compared to 8 percent modifier. The ductility values decrease with increase in percentage of modifier.

4. Viscosity

When bitumen is blended with polymer, a multi phase system is formed; one such phase is rich in asphaltenes not absorbed by the polymer which enhances the viscosity by the formation of more complex internal structure. The flow behavior of a bituminous material described in terms of viscosity, exhibits Newtonian and non-Newtonian characteristics depending on the composition and source of the crude .Temperature and loading also affect the behavior describing the viscoelastic properties of the material. In VG 30 grade bitumen with viscosity of 60^0 C shows increase in viscosity with the increase in polymer concentration. However, Non-Newtonian behavior is observed with the decrease in viscosity as shear rate increases for polymers at 8% concentration. This non-Newtonian phenomenon is dependent on the internal structure of the Polyethylene.

Fig 1 Properties of Modified Bituminous Mix



Thus the increase in percentage of polymer decreased the penetration value. This shows that the when plastic are start adding the bitumen hardness are increases. Also the penetration values of the bituminous mix are decreasing this is depending upon the percentage of polyethylene by weight are added. The ductility

decreased by the addition of plastic waste to bitumen. The decrease in the ductility value is due to binding properties of ethene monomers molecules with bitumen. The softening point of the bituminous mix is also increased by the addition of polyethylene into the bitumen. With increasing the percentage of plastic waste by weight the softening point is also increases. The increment in softening point may be due to the chemical nature of plastic waste are added. The increase in the softening point shows that there will be less bleeding during summer. So friction was reduces for the moving vehicles and on the other side, if it rains the bleedings accounts for the slippery condition. Both these adverse conditions are much reduced by plastic-bitumen blend.

5. MARSHALL TEST RESULTS ON BITUMINOUS MIXES

The Marshall stability is a measure of structural strength of a bituminous mix. Higher the stability of the mix, greater will be the strength of surfacing. From the values given in table 5 it can be seen that the Marshall stability increases when the bitumen content is increased from 5 percent to 5.5 % and then it decreases at 6% bitumen content. The increase in stability is due to the improvements in the physical properties of bitumen and the coating of the aggregates with the plastic fibers. Here also, the Marshall Stability increased with an increase plastic percent in the bitumen content. Stability and Flow value graphically in figure 3 and 4 respectively.

Fig. 2 Testing of Marshall Specimen

Table 5 Comparison between plain bitumen and modified bitumen

Bituminous mix contain by wt. Of aggregate	VG 30 grade bitumen		8 % bitumen replaced by plastic waste		5 % bitumen replaced by plastic waste	
	Stability in KN	Flow in mm	Stability in KN	Flow in mm	Stability in KN	Flow in mm
5 percent	17.18	4.23	20.28	4.43	18.18	4.29
5.5 percent	17.68	4.40	21.43	4.95	19.85	4.73
6 percent	17.61	5.10	20.89	5.15	18.90	5.12

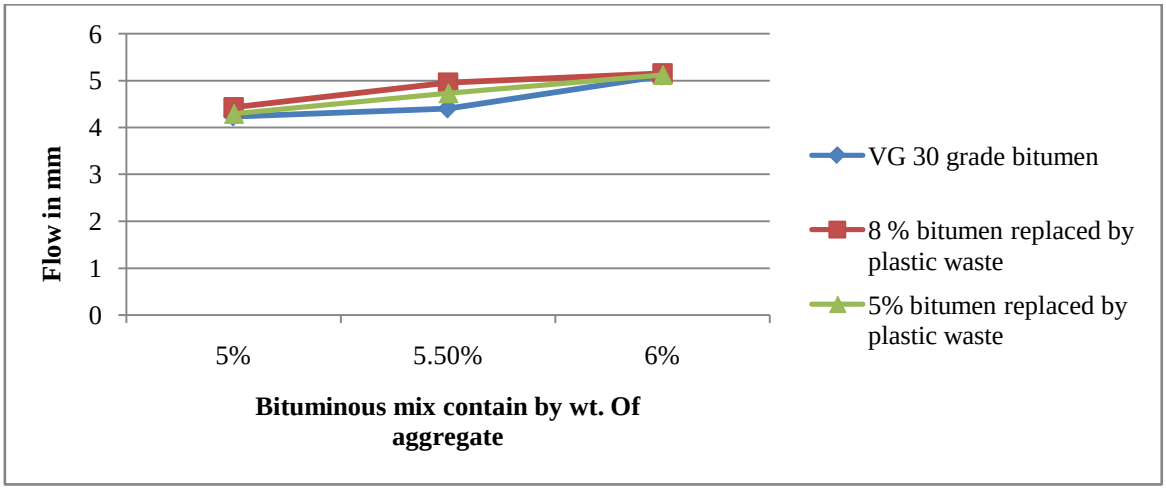


Fig. 2 Marshall Stability

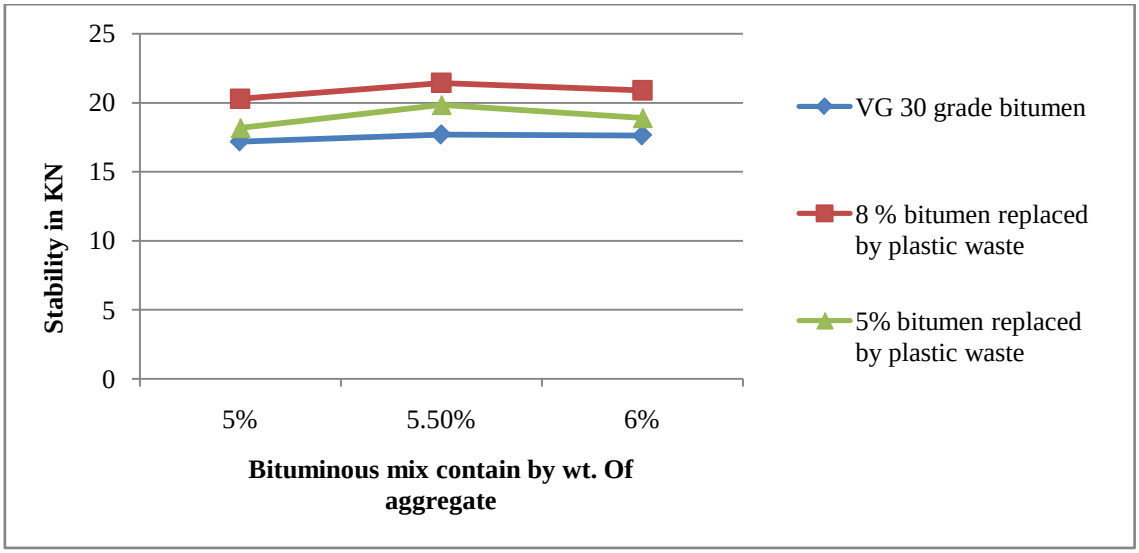


Fig 3 Flow value

6. ECONOMIC ANALYSES

A huge quantity of plastic waste has been used as modifying agents. Table 6 shows that material cost comparison analyses for 1 km. It is show that if we use 8% of plastic by weight in the bitumen we save approximately 52769 Rs. per kilometer means it reduces material cost up to 4.3%. From an environmental and economic standpoint, the use of waste plastic fibers as a bitumen-modifying agent may contribute to solving a waste disposal problem and to improving the quality of road pavements.

Table 6 Economic Analyses of plastic Road

Description	Unit	Rate/unit (approx.)	For control mix		For modified mix sample	
Material			quantity	Amount(Rs)	quantity	Amount(Rs)
Aggregate	Ton	800	440.571	352456	428.881	343104
Bitumen	Ton	32000	26.992	863680	24.831	794560
Stone dust	Ton	350	23.191	8116.5	22.571	7899.5
Plastic waste	Ton	12000			2.161	25920
Total material cost				1224252.5		1171483.5
Total material cost reduction=4.3%						

7. CONCLUSION

The addition of waste plastic in the bitumen to modify the properties of bitumen and this modified bitumen shows good result when compared to standard results. The properties of bitumen such as penetration softening point improved with the addition of the waste plastic and ductility value decreases with increase in percentage of plastic modifier, but the rate of decrease is less after addition more than 8% of the plastic waste. The optimum content of waste plastic to be used is between the ranges of 5% to 10%. Due to addition of plastic problems like bleeding are reduce in hot temperature region.

Plastic has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic. The waste plastics thus can be put to use and it ultimately improves the quality and performance of road. The plastic roads are good tensile strength, less in rutting, better in durability in comparison to the ordinary road and the total material cost of the project is reduced. Therefore modified bituminous materials can bring real benefits to highway construction, maintenance, in terms of better and longer lasting roads, and savings in total road life costing.

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