

Utilization of Plastic Waste in Bituminous Road Construction

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ABSTRACT

With the rapidly growing of the population and development activities the amount of plastic waste in municipal solid waste is increasing, which leads to widespread littering on the landscape. When the used plastic material is thrown out, it does not undergo bio decomposition. As the plastic wastes are durable and non-biodegradable, the improper disposal of plastic may cause many health issues for both animals and humans. Hence, it is needed that plastic products must be recycled and not end in landfills. There are many available methods to stop this plastic pollution. Plastic pavement will be a better solution to the above stated problems. In this method, plastic waste is mixing with bitumen to construct modified bituminous roads. Proper addition of such waste in bitumen improves quality, life and minimizes construction cost of road. This waste modified bitumen mix show better binding property, stability, density and more resistant to water. The aim of this study is to reduce the waste plastic material and reuse in flexible road construction to make road construction more economical and eco-friendly. Here, plastic wastes of size 13mm x 13mm are added into bitumen in different proportion of 10%, 15% and 18% as a modifier. The laboratory test result shows the improvement in different engineering properties of bitumen, like Penetration value, Ductility, Softening point value and Marshall Stability value of modified bituminous mixes for different percentage of plastic i.e. 10%, 15%, and 18% of plastic mix as compared to unmodified mix.

Keywords: - Plastic waste, municipal solid waste, eco-friendly, flexible pavements, modified bitumen, Marshall Stability test

I. INTRODUCTION

The use of plastic materials such as plastic bottle, carry bags, cups, etc. increasing rapidly day by day. Plastic is a non-degradable waste, causes greenhouse effect and global warming. Disposal of waste plastic bottle has become a serious problem, especially in urban area, in terms of its issue its dumping in the dustbins clogging of drains reduced soil fertility and aesthetic problems etc. and waste plastics are burnt for apparent disposal which cause environmental pollution. Therefore these waste plastic is either landfilled or incinerated. Both these activities are not eco-friendly as it pollutes the land and the air. Since the polythene are not biodegradable, the need of the present time is to use the waste plastic in some beneficial purposes. The use of these materials as a road construction proves eco-friendly, economical and use of plastic gives strength in the sub-base course of the pavement. [Chhabra,R.S., 2014]. Utilization of waste plastic in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems.

The various experiments have been carried out whether the waste plastic can be reused productively. Along with bitumen, use waste plastic increases its life and smoothness. It is economical and eco-friendly. Addition of plastic waste in construction of pavements reduces the plastic shrinkage and drying shrinkage. Plastic waste can be handled and used successfully in the construction of roads thus mitigating the environmental problems and economize the cost of construction of road with in the country. The use of waste plastic improves the abrasion and slip resistance of asphalt pavement. In India, plastic pavement has of greatest advantage because of hot and extremely humid climate. The advantages of plastic mixed bitumen are discussed as below-

- Reduce the need of bitumen by around 10-15%.
- Develop a technology which is eco-friendly.
- Improvements in fatigue life of roads.
- Increase the strength and better performance of the road.
- Use higher percentage of plastic waste.
- The gases released during traffic conditions are absorbed by smoke absorbent.

II. LITERATURE REVIEW

The polymer bitumen blend is a better binder compare to the plain bitumen. Blend has increase softening point and decreased the penetration value with a suitable ductility. [Rajasekaran S,] When it is used for road construction it can withstand higher temperature and load the coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate mix shows higher Marshal stability value and suitable marshal coefficient Hence the use of waste plastic for the flexible pavement is one of the best method of easy disposal of waste plastic. Use of plastic bags in road helps in many ways like easy disposal of waste, better road prevention of pollution and so on. [Panda M. and Mazumdar M. 1999]. Various additives like polymers and fibers have been utilized for purpose of improving the characteristics of bitumen composition, as well as to improve their toughness and durability. Additives such as styrene based polymers, polyethylene based polymers gilsonite, various oils, and many other modifiers including tall oil have been added to bitumen to enhance various engineering properties of bitumen. [Bindu C. S and K. S Beena]. Some encouraging results were reported in that study that there is possibility to improve the performance of bituminous mix of road pavement. (Waste plastics polythene carries bags, etc.) on heating soften around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in temperature range of 130-180°C. Softened plastics have binding a property. Hence it can be used for road construction. [Vidula S Abhijit Jigre]. The various literature indicated that the waste plastic when added to hot aggregates will form a fine coat of plastic over the aggregate and such aggregates when mixed with binder is found to have higher strength, higher resistance and better performance over a period of time. The laboratory studies conducted by CRRI in Utilization of waste plastic bags in bituminous concrete mixes have proved that these enhance the properties of mix in addition to solving disposal problem. This indicated that there was an improvement in strength properties when compared to a conventional mix. Therefore, the life of pavement surfacing using the plastic waste is expected to increase substantially in comparison to the use of conventional bitumen mix. The polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased softening point and decreased Penetration value with a suitable ductility [Vasudevan,R.,2007]. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix shows better binding property, stability, density and more resistant to water. [Gawande, A., 2012]

III. OBJECTIVES:

The main objectives of the present study are:

- To reduce the bitumen content by the addition of waste plastic in bituminous mix and hence to make the bituminous road construction more economical and eco-friendly.
- To study the effect on Penetration, Ductility, Softening point and Marshall Stability value of bituminous mix with the addition of waste plastic.

IV. METHODOLOGY

Waste plastic bottles were collected from houses, roads, garbage truck, dumpsite, and waste-buyers. The collected waste plastics were shorted and cut into small pieces of required sizes of 13mm x 13mm. These small pieces of plastics were mixed slowly to the hot bitumen at higher temperature (160°C-170°C) for different percentage of plastic i.e. 10%, 15%, and 18% of waste plastic. The mixture was stirred manually for uniformly mixing. Prepared plastic bitumen mixture were used for carrying out the different laboratory tests to determine the different engineering properties of bitumen, like Penetration value, Ductility value, Softening point value and Marshall Stability value.

V. RESULT AND DISCUSSION

On the basis of various experimental tests performed on bitumen and plastic mix for different percentage of plastic waste i.e. 10%, 15%, and 18% of plastic waste following test results are obtained.

Table 1 Results of various experimental tests performed on bitumen and plastic mix for different percentage of plastic

S. No.	Test Conducted	Plain bitumen	Modified bitumen mixed with different percent of plastic		
		0% plastic	10% plastic	15%plastic	18%plastic
1	Penetration test	60-70mm	66.2mm	63.5mm	60.7mm
2	Ductility test	100mm	95.5mm	89.3mm	85.5mm
3	Softening point test	48-56°C	50.9°C	53.2°C	56.7°C

4	Marshall Stability test (in kg)	1492	1453	1387	1245
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a. Penetration test

Penetration value indicates the softness of bitumen, higher the penetration, softer is the bitumen. Penetration test was conducted as per IS 1203:1978 The penetration value is the distance in tenths of millimetre, that a standard needle will penetrate into the bitumen under a load of 100gm applied for 5 seconds at a standard temperature of 25 °c. The variation of Penetration value of plastic mixed bitumen is shown in Fig. 1

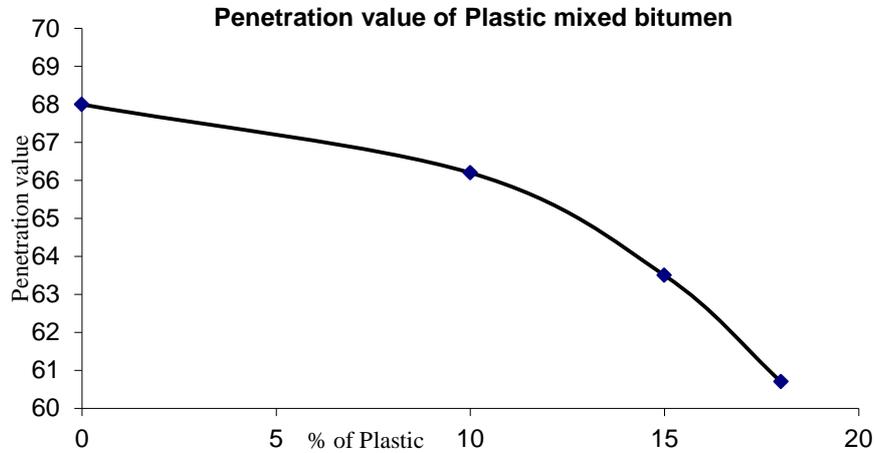


Fig. 1 Variation of Penetration value of Plastic mixed bitumen

From the figure, it is observed that the penetration value of plastic mixed bitumen decreases with increase of the percentage of plastic waste chips which shows that the addition of polymer increases the hardness of bitumen. Significant decrease in penetration value for modified bitumen indicating the improvement in their temperature susceptibility resistance characteristics and lower penetration grade bitumen is preferred in hot climate area.

b. Ductility test

Ductility is the property of bitumen which allows it to undergo deformation or elongation. The ductility of bitumen is measured by the distance in cm to which the bitumen sample will elongate before breaking when it is pulled by standard specimen at specified speed and temperature. The ductility of bitumen may vary from 5 to over 100. Ductility test was conducted as per IS 1208:1978. The variation of ductility value for different percentage of plastic mix is shown in fig. 2. Figure shows that the ductility value of plastic mixed bitumen decreases with the increase of percentage of waste plastic to the bitumen. The decrease in ductility value may be due to interlocking of polymer molecules with bitumen. The ductility value less then 50 mm should not be used in road construction but may be used as crack and joint filler material.

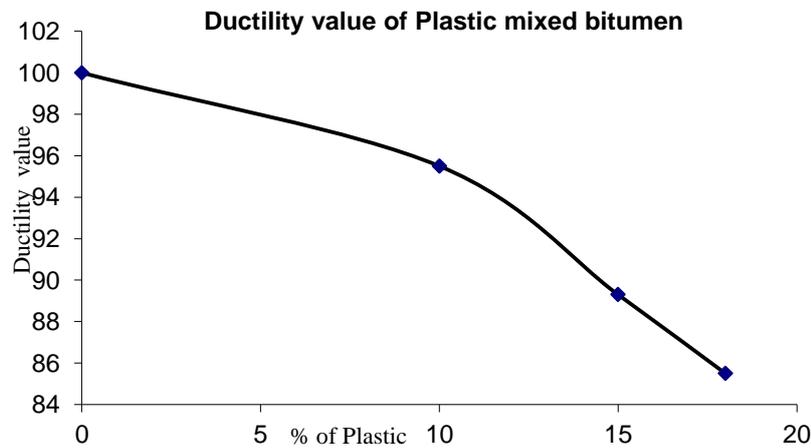


Fig. 2 Variation of Penetration value of Plastic mixed bitumen

c. Softening point of bitumen

Softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test. The test is conducted by ring and ball apparatus. Softening point test was conducted as per IS1205:1978 Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

The variation of Softening point value for different percentage of plastic mix is shown in fig. 3. Figure shows that the softening point value increases with the increase of waste plastic to the bitumen. The influence over the softening point may be due to chemical nature of polymer added. The increase value of softening point shows that there will be less bleeding during summer.

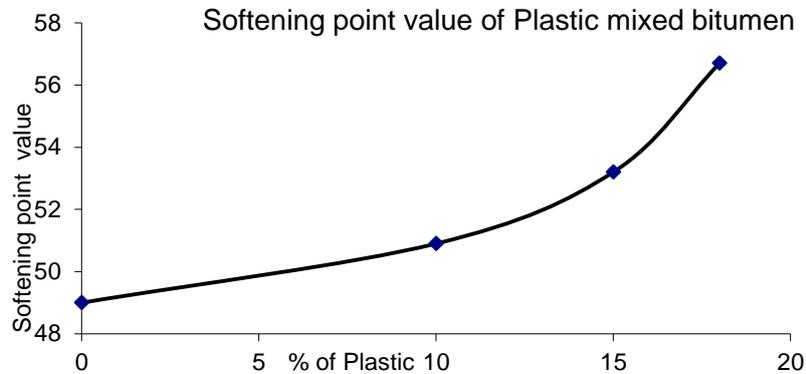


Fig. 3 Variation of Penetration value of Plastic mixed bitumen

d. Marshall stability value of Bitumen

Marshall stability test is the performance prediction measure conducted on the bituminous mix. Marshall stability value measures the maximum load sustained by the bituminous material at a loading rate of 50.8 mm/minute. The mix design should aim at an economical blend, with proper gradation of aggregates and adequate proportion of bitumen so as to fulfill the desired properties of mix. The test load is increased until it reaches a maximum. Beyond that, when the load just starts to decrease, the loading is ended and the maximum load (i.e. Marshall stability) is recorded.

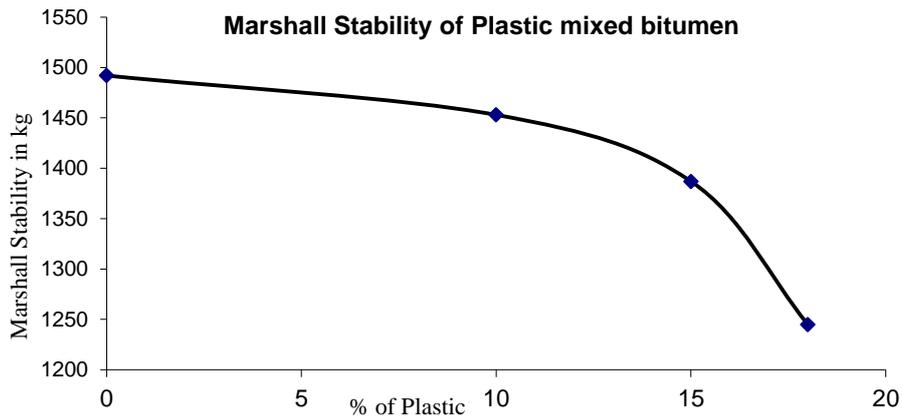


Fig. 4 Variation of Penetration value of Plastic mixed bitumen

The variation of Marshall Stability value for different percentage of plastic mix is shown in fig. 5. Figure shows that the stability value of plastic mixed bitumen decreases with the increase of percentage of plastic increases. Figure shows that the 10% to 15% percent of plastic waste indicate the suitable stability so that 10 to 15% percentage of plastic waste can be use in flexible road construction.

VI. CONCLUSION:

On the basis of the results of experimental investigation made above, following conclusions may be drawn.

1. The use of plastic waste chips into the bituminous road is economical and eco-friendly.
2. The penetration value of plastic mixed bitumen decreases with increase of the percentage of plastic

waste chips which indicates the increment of the hardness of bitumen and lower penetration grade bitumen is preferred in hot climate area.

3. The ductility value of plastic mixed bitumen decreases with the increase of percentage of waste plastic to the bitumen. The decrease in ductility value may be due to interlocking of polymer molecules with bitumen.

4. The softening point value increases with the increase of waste plastic to the bitumen. The increase value of softening point implies that there will be less bleeding during summer.

5. The Marshal Stability value of plastic mixed bitumen decreases with the increase of percentage of plastic increases. A mix of 10% to 15% percent of plastic waste indicates the suitable stability of bitumen and can be used in flexible road construction.

6. In India polymer (waste plastic) modified binder could be a better solution due to its low ductility, high softening point and enhanced elastic properties.

7. As waste plastic modified bituminous road has the potential to make pavement long lasting, and economical, it holds a huge potential and a great prospect in prevailing hot weather conditions in India.

8. The plastic mixed with bitumen and aggregates is used for the better performance of the roads. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement.

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