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A STUDY ON USE OF WASTE PLASTIC IN BITUMINOUS PAVING MIXES

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Abstract: The idea of using waste plastics in road construction is relatively new. Laboratory tests have shown positive results when a small amount (10-15% by weight) of plastic is incorporated in bituminous mixes (asphalt), resulting in improved pavement stability, strength, and durability. However, international field experience using plastics in actual road construction is quite limited. While roads constructed using waste plastics have shown good longevity and pavement performance to date, the first roads constructed using this technology are only about ten years old, so long-term outcomes are not yet clear. The mix polymer coated aggregate and modified bitumen have shown higher strength. Use of this mix for road construction helps to use plastics waste. Once the plastic waste is separated from municipal solid waste, the organic matter can be converted into manure and used. Our paper will discuss in detail the process and its successful applications**.**

Keywords: **Modified bitumen,** Bituminous mixes, **Road construction**

I. INTRODUCTION:

India generates 1, 88,000 tons garbage every day. Plastic Waste in different forms is found to be almost 9% to 12% in municipal solid waste, which is toxic in nature. Non-biodegradability of plastic in the environment has created numerous challenges for both urban and rural India. Common problems are choking of drains, stagnation of water, release of toxic gases upon open incineration. Research experiments in the public and private sector have been undertaken to address the growing environmental challenge.

The technical objectives also included understanding the scientific background and process, assessing relevant guidelines and rules of the Indian road Congress, use of alternative materials, assessing the integration of technological and engineering decision of use, road construction into the policy framework and execution The scope of the project was limited by the focus of plastics in road construction as identified by the India Road Congress Standard SP-98. The evaluation aspects included Technical, Financial, Organisation and Administrative aspects. 3 field visits were the limited to the most performing states. The scope of technical assessment was limited to desktop scientific research and no experiments were to be conducted. The methodology applied was participatory and applied. Methods included primary research, secondary research, interviews and focus group discussions.

Bitumen plays an important role in binding the aggregate together by coating over the aggregate thereby imparting strength to the road. However, due to poor resistance towards water and high costs involved, there is a demand for high quality bitumen at low costs. This can be accomplished by modifying the rheological properties of bitumen by using additives such as plastic or rubber. Plastic waste can be used in hot mix to improve physical properties of bituminous aggregate mix by 'Dry Process' or 'Wet Process'. The technology as developed incorporates the use of 'Plastone', a mixture of stone chips and waste plastic bags (thickness 40-70 μm) which is heated at 150-170 degree C during production, in laying roads, pavements and flooring purposes as an alternative to interlocking paver blocks. At this processing temperature, the plastic waste is heated enough to act as an adhesive in binding stone chips and not generating any toxic gases. The aggregate becomes water proof after getting coated with molten plastic. This step is followed by the addition of hot plastic-aggregate mix to hot bitumen while maintaining the process temperature. This approach is known as 'Dry Process'. The 'Wet Process' involves mixing of plastic to hot bitumen followed by mixing with hot aggregate. Both the processes lead to the formation of plastic modified bituminous aggregate mix with enhanced properties imparting strength, stability and durability to the roads.

Plastic-tar roads have benefits over conventional roads such as the overall reduction in bitumen consumption by 8%, enhanced load carrying strength, reduced wear and tear, prevents release of 3 tonnes of CO2 (through disposal by burning) into the atmosphere, increased road strength, excellent resistance to water and water stagnation, no stripping and potholes formation, enhanced binding, reduced rutting

and ravelling, improved soundness property, negligible maintenance cost of the road, no leaching of plastics and no effect of UV radiation. Waste plastic that can be used include cups, carry bags, polythene and polypropylene foams and thermocol. Polyvinylchloride cannot be used as it is toxic in nature.

II. LITERATURE REVIEW:

Most of the researches have worked in publishing their work on use of Plastic Waste as material in road construction for improving the strength of pavement. The observation, methodology, conclusions and further scope of work are used to finalise the objectives of present work. The available literature of review is as follows :

Vidula Swami, *at el*, (2012) The addition of waste plastic modifies the properties of bitumen. The modified bitumen shows good result when compared to standard results. The optimum content of waste plastic to be used is between the range of 5% to 10%.The 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. Total material cost of the project is reduced by about 13%.

Azmat Shaikh, et al, (2017), From the study of the behavior of plastic waste modified BC, we can conclude that the modified mix possesses improved Marshall Characteristics. It is observed that Marshall Stability value increases with plastic content and we observed that the Marshall Flow value decreases upon addition of polythene i.e. the resistance to deformations under heavy wheel loads increases. From all the experiments performed we can conclude that the addition of plastic waste enhances the various properties of an ordinary bituminous road. Considering these factors we can assure that we can obtain a more stable and durable mix for the pavements by polymer modifications. This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed of by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly.

Chinthayyanaidu Rudram(2018), When it is compared the dry and wet process it is most effective to use dry process why because in dry process we can use up to 15% of plastic waste and binding also more with aggregate, where as in wet process we can use only up to 10% beyond this we can't use because it requires much mechanical energy, and stability is average. Marshal stability values of dry process are much better than the wet process, so in practical situation Dry Process is more suitable.

III. METHODOLOGY:

1. Waste plastic bags were collected from roads, garbage trucks, dumpsites and compost plants, ragpickers, waste-buyers costing at Rs 12-15 per kg.
2. Household plastic was also collected for the project work, like empty milk bags, used plastic bags etc. The collected Plastic waste was sorted as per the required thickness. Generally, polyethylene of 60 micron or below is used for the further process.
3. Less micron plastic is easily mixable in the bitumen at higher temperature (160°c-170°c).It is clean by de-dusting or washing if required.
4. Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected.
5. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp.
6. Pieces were added slowly to the hot bitumen of temperature around 160-170°c.The mixture was stirred manually for about 20-30 minutes. In that time period, temperature was kept constant about 160-170°c.
7. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out tests i.e. Penetration test, Ductility test, Flash point test & Fire point test, Stripping test, Ring and ball test and Marshall Stability value test.

IV. RESULT & DISCUSSION:

The increase in percentage of polymer decreased the penetration value. This shows that the addition of polymer increases the hardness of the bitumen.The penetration values of the blends are decreasing depending upon the percentage of polymers and the type of polymer added.The ductility decreased by the addition of plastic waste to bitumen. The decrease in the ductility value may be due to interlocking of polymer molecules with bitumen. Flash and fire point increased with the increase in the percentage of polymer .The polymer bitumen blend road surfaces are less affected by fire hazards. This shows that the blend has better resistance towards water. This may be due to better binding property of the polymer bitumen blend. The softening point increased by the addition of plastic waste to the bitumen. Higher the percentage of plastic waste added, higher is the softening point. The influence over the softening point may be due to the chemical nature of polymers added. The increase in the softening point shows that there will be less bleeding during summer. Bleeding accounts, on one side, increased friction 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 polymer-bitumen blend.

SUMMARY OF MARSHALL STABILITY TEST :

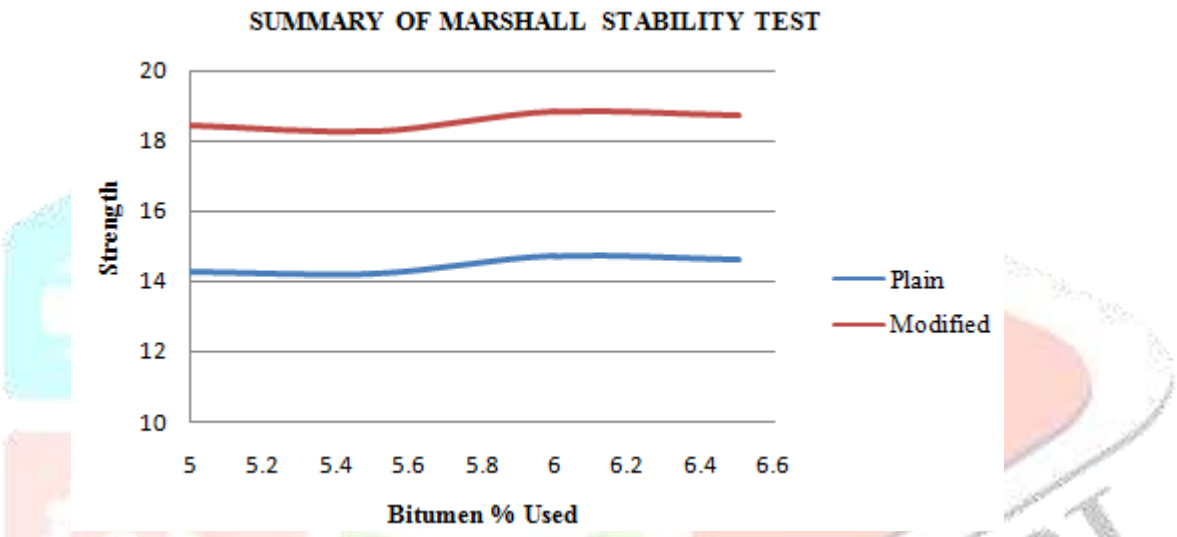
Mix design for bitumen:

The Marshall Quotient is also within the range of tolerance, thus showing that the plastic waste (polyethylene) blended bitumen mix is better and more suitable for flexible pavement construction.

Table4.1 Summary of Marshall Stability test

Bitumen used	Strength	
	Plain Bitumen	15% Bitumen replaced by Plastic waste
5.0	14.30	18.43
5.5	14.21	18.28
6.0	14.71	18.82
6.5	14.62	18.71

Graph 4.1 Summary of Marshall stability test

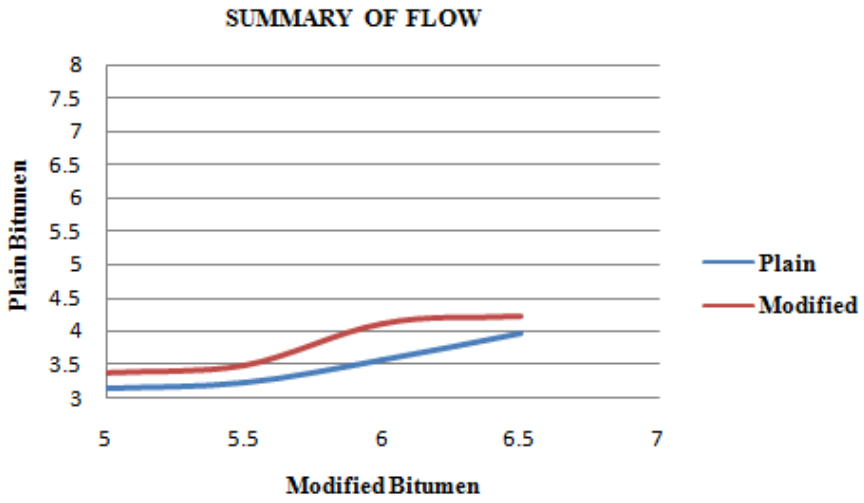


SUMMARY OF FLOW:

Table4.2 Summary of Flow

Bitumen used	Flow	
	Plain Bitumen	15% Bitumen replaced by Plastic waste
5.0	3.14	3.36
5.5	3.22	3.48
6.0	3.56	4.12
6.5	3.98	4.22

Graph 4.2 Summary of Flow



Comparison between Plain bitumen and Modified bitumen (15% plastic waste)

Table4.3 Test Results

S.No.	Test Conducted	Results			
		Plain bitumen		Modified bitumen (15% Plastic mixed)	
1.	Ductility	82 mm		58 mm	
2.	Flash point	245°C		260°C	
3.	Fire point	253°C		290°C	
4.	Penetration test	69 mm		58 mm	
5.	Stripping value	0.4%		0.1%	
6.	Softening point	Temp.in °C	Time in sec	Temp. in°C	Time in sec
		55	358	68	570

Cost analysis for materials as per km construction:

Table4.4 Cost Analysis

Description	Unit	Rate/Unit	For Plain Mix		For Modified Mix	
			Quantity	Amount(Rs)	Quantity	Amount(Rs)
Material	-	-	-	-	-	-
Aggregate	Ton	634	563.70	357385.80	479.15	303781.10
Bitumen	Ton	85000	32.80	2788000.00	27.88	2369800.00
Plastic waste	Ton	14000			4.32	60480.00
Total material Cost				3145385.80		2734061.10
Total material cost reduction = 13.07%						

V. CONCLUSION:

- The addition of waste plastic modifies the properties of bitumen.
- The modified bitumen shows good result when compared to standard results.
- The optimum content of waste plastic to be used is between the range of 10% to 15%.
- The 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.
- Total material cost of the project is reduced by 13.07 %.

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