

Use of waste plastic in construction of bituminous road

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ABSTRACT:

Bottles, containers and packing strips etc. is increasing day by day. As a result amount of waste plastic also increases. This leads to various environmental problems. Many of the wastes produced today will remain in the environment for many years leading to various environmental concerns. Therefore it is necessary to utilize the wastes effectively with technical development in each field. Many by-products are being produced using the plastic wastes. Our present work is helping to take care of these aspects. Plastic waste, consisting of carry bags, cups and other utilized plastic can be used as a coating over aggregate and this coated stone can be used for road construction. The mix polymer coated aggregate and tyre 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.

INTRODUCTION:

Now-a-days disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable. Traditionally soil, stone aggregates, sand, bitumen, cement etc. are used for road construction. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, and industrial wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low-volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement.

Post construction pavement performance studies are to be done for these waste materials for construction of low volume roads with two-fold benefits: (a) it will help clear valuable land of huge dumps of wastes; (b) it will also help to preserve the natural reserves of aggregates, thus protecting the environment. Plastics are user friendly but not eco-friendly as they are non-biodegradable generally, it is disposed by way of land filling or incineration of materials which are hazardous. Plastic is versatile material and a friend to common man becomes a problem to the environment after its use. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics.

Road surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate, possess fewer loads bearing capacity and can cause serious damages because of higher axle load in present conditions due to rapid infrastructure development. Useful life of bituminous overlays has reportedly declined 7-8 from average life of 5-6 years in the past to about 3-4 years at present as compared to average pavement life (5-6 years) in abroad. India has to raise transportation system to a higher level both in terms of length and quality. This study presents the use of waste in hot bituminous mixes to enhance pavement performance, protect environment and provide low cost roads.

Polymer and plastic modified bitumen, often abbreviated as modified bitumen is obtained with the incorporation of selected thermoplastics and shredded plastic from discarded waste, natural plastic or any other suitable elastomers in bitumen.

Literature review:

Prof.C.E.G. Justo States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter (m³) of BC mix. Modified Bitumen improves the stability or strength, life and other desirable properties of bituminous concrete mix.

Dr. R. Vasudevan states that 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. When it 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 bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution and so on.

According to **V.S. Punith**, (2001), Some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction.**Sundaram & Rojasay** (2008) studied the Effective blending technique for the use of plastic waste into bitumen for road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests.**Verma S.S.** (2008). concluded that Plastics will increase the melting point of the bitumen. This technology not only strengthened the road construction but also increased the road life.

Dr. R. Vasudevan and S. Rajasekaran, (2007) stated that 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.

Mohd. Imtiyaz (2002) concluded that the mix prepared with modifiers shows:-Higher resistance to permanent deformation at higher temperature. **Sabina et al** (2001) studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by wt of bitumen) with conventional bituminous concrete mix (prepared with 60/70 penetration grade bitumen). Improvement in properties like Marshall Stability, retained stability, indirect tensile strength and rutting was observed in Plastic modified bituminous concrete mixes.

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 problems. The results indicated that there was an improvement in strength properties when compared to a conventional mix. Therefore, the life of pavement surfacing using the waste plastic is expected to increase substantially in comparison to the use of conventional bituminous mix.

METHODOLOGY:

Waste plastic bags were collected from roads, garbage trucks, dumpsites and compost plants, rag-pickers, waste-buyers at Rs 5-6 per kg. 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. 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. 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. 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 20-30 minutes. In that time period temperature was kept constant about 160-170°C. 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.

RESULTS:

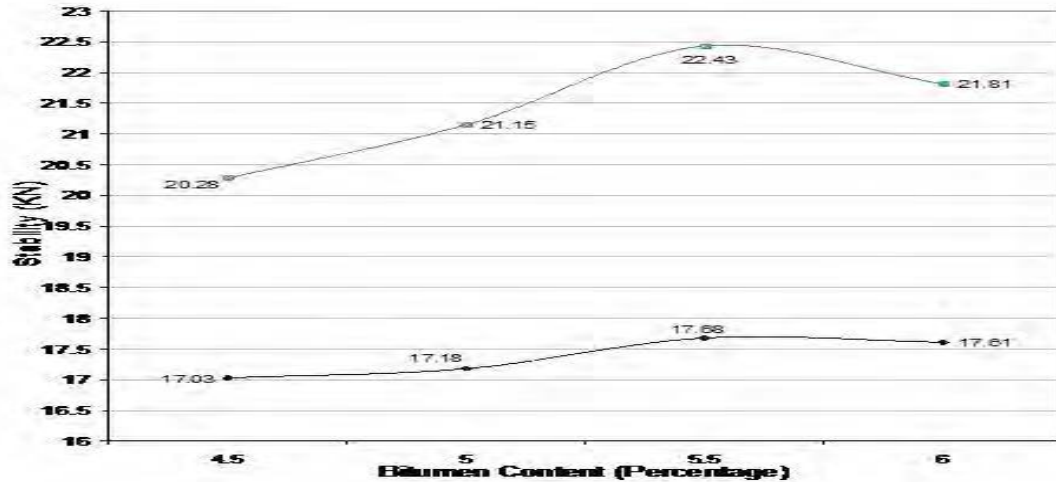
The increase in percentage of polymer decreased the penetration value. This shows that the addition of polymer increases the hardness of the bitumen. The penetration values of the blends are decreasing depending upon the percentage of polymers and the type of polymer added. The ductility decreased by 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:

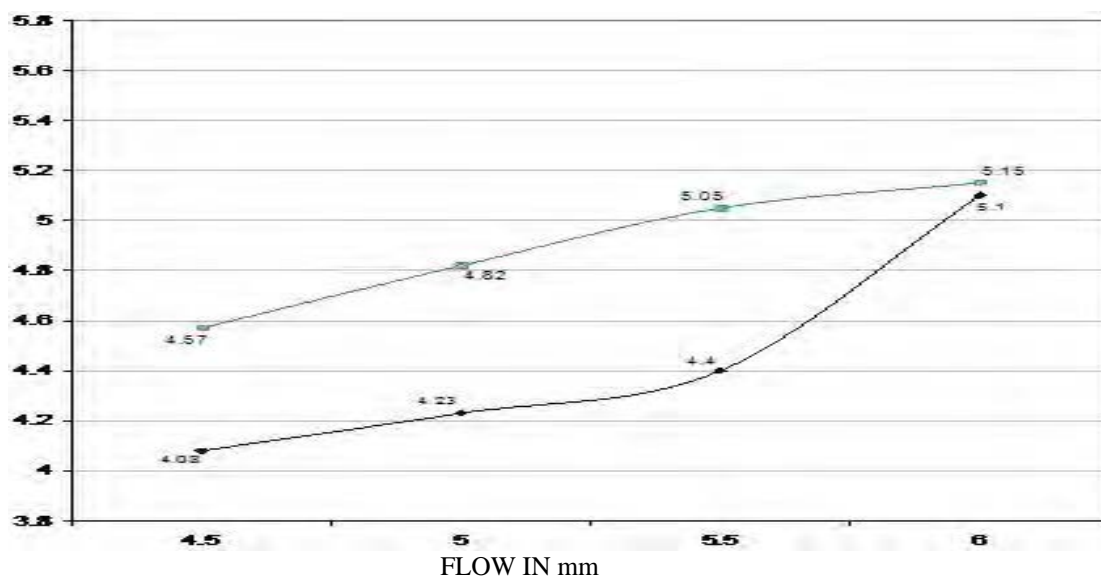
The Marshall Quotient is also within the range of tolerance, thus showing that the plastic waste (polyethylene) blended bitumen mix is better and more suitable for flexible pavement construction.



Bitumen Content	Stability (KN)	
	Plain bitumen	10 % bitumen replaced by plastic waste
4.5 Percent	17.03	20.28
5.0 Percent	17.18	21.15
5.5 Percent	17.68	22.43
6.0 Percent	17.61	21.81

SUMMARY OF FLOW:

Bitumen Content	Flow (mm)	
	Plain bitumen	10 % bitumen replaced by plastic waste
4.5 Percent	4.08	4.57
5.0 Percent	4.23	4.82
5.5 Percent	4.40	5.05
6.0 Percent	5.10	5.15



FINDINGS:

Sr.no	Tests conducted	Test results			
		Plain bitumen		Modified bitumen (10% plastic replaced)	
1.	Penetration test	68mm		58mm	
2.	Ductility	83mm		52mm	
3.	Flash point	235°C		260°C	
4.	Fire point	251°C		295°C	
5.	Stripping value	0.4%		0.0%	
6.	Softening point	Temp.in°C	Time in sec	Temp.in°C	Time in sec
		53	334	64	550

Comparison between plain bitumen and modified bitumen (10% plastic waste)

Material cost comparison for 1km road:

Description	Unit	Rate/unit	For control mix		For modified sample	
			quantity	Amount(Rs)	quantity	Amount(Rs)
material						
Aggregate	Ton	597	545.06	325400.88	495.65	295903.05
Bitumen	Ton	35000	31.78	1112300	28.85	1009750
Plastic waste	Ton	6000			2.885	17310
Total material cost				1437700.88		1322963.05
Total material cost reduction=7.99%						

SIGNIFICANCES:

The polymer bitumen blend is a better binder compared to plain bitumen. The blend has increased Softening Point and decreased Penetration Value with a suitable ductility. When used for road construction it can withstand higher temperature. Hence it is suitable for tropical regions. It has decreased Penetration Value. Hence its load carrying capacity is increased. The blend with aggregate has no Stripping Value. So it can resist the effect of water. The Marshall Stability Value is high. The bitumen required can be reduced depending upon the % of polymer added. It is a good saving too. No toxic gas is produced. Disposal of waste plastic will no longer be a problem. The binding properties of polymer also improve the strength of mastic flooring. The use of waste plastics on the road helps to provide better place for burying the plastic waste without causing disposal problem. At the same time, a better road is also constructed. It also helps to avoid the general disposal technique of waste plastics namely land-filling and the incineration, which have certain burden on ecology.

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 5% to 10%.
- The problems like bleeding are reduced in hot temperature region.
- Plastic has property of absorbing sound, which also helps 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 7.99%

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