USE OF PLASTIC IN BITUMINOUS ROAD CONSTRUCTION

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ABSTRACT **:** *Bottle, 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. Therefore it is necessary to utilize waste effectively with technical development in each field. Many by-products are being produced using the plastic wastes. 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 plastic waste effectively. Now a day's waste plastic is used in bituminous road construction. This technology is not a new concept but rather not practiced widely.

INTRODUCTION

Plastic are user friendly but not eco-friendly as they are non-biodegradable. Today in INDIA nearly more than 12 million tones of plastics are used. There visibility has been perceived as a serious problem and made plastic a target in the management of solid waste. They also have a very long lifetime and burning of plastics waste under uncontrolled conditions could also lead to generation of many hazardous air pollutant(HAPs) depending upon the type of polymers and additives used.

Polymer modified bitumen is emerging as one of the important construction of

flexible pavement. The polymer modified bitumen show better properties for road construction and plastic waste can find its use in this process and this can help solving problem of pollution. The better binding property of plastic in its molten state has helped in finding out a method of safe disposal of waste plastic.

Roads surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate posses fewer loads bearing capacity and can cause serious damages because of higher axial load in present conditions due to rapid infrastructure development. India has to raise transportation system to a higher level both in terms of length and quality .The use of waste in hot bituminous mixes too enhance pavement performance, protect environment and provide low cost roads.

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 (m 3) 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.

Mohd.Imtiyaz(2002) concluded that the mix prepared with modifiers shows:-Higher resistance to permanent deformation at higher temperature.

Sabinaetal (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.

Sundaram&Rojasay(2008) studied the Effective blend 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.

CHARACTERISTICS OF PLASTIC WASTE:

Thermal Study:

A study of the thermal behavior of the polymers namely polyethylene, polypropylene, polystyrene, shows that those polymers get softened easily without any evolution of gas around 130-140^{0}C, this has been scientifically verified. At around 350^{0}C they get decomposed releasing gases like methane, ethane etc and at 700^{0}C they undergo combustion, producing gases like CO and CO_2.

Binding Property:

The molten plastic waste inhibits good binding property. Following experiments were carried out to study the binding property. The aggregate was heated to around 170^{0}C and the shredded plastic waste was added. Plastics got softened and coated over the aggregate. The mix of aggregate and plastic was compacted and cooled. The block was very hard and showed compressive strength not less than 130 MPa and binding strength of 500 kg/cm^2. This shows that the binding strength of the polymer is good.

The polymer coated aggregate was soaked in water for 72 hours. There was no stripping at all. This shows that the coated plastic material sticks well with the surface of the aggregate

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METHODOLOGY:

a) Wet Process:

1) Waste plastic bags collect first.
2) Collected plastic waste sorted as required thickness.
3) Normally polyethylene 60 micron or below is used for the further process.
4) Generally less micron plastic is easily mixable in the bitumen at higher temperature (160-170^{o}c)
5) Collected plastic was cut into fine pieces as far as possible.
6) Then sieve it through 4.75mm sieve and retain on 2.36mm sieve was collected.
7) First bitumen heated at about 160-170 c temp. which is melting temperature.
8) Then piece were added into this.
9) At constant temp. mixture was stirred manually for about 20-30min.
10) Polymer bitumen mixture of different composition were prepared & used for carrying out diff. test i e. Penetration test, ductility test, flash point test & fire point test, stripping test, ring &ball test and marshall stability test.

EXPERIMENTAL TEST

Determination of Softening Point (IS:1205-1978)

The softening is the temperature at which the substance attains a particular degree of softening under specified condition of test. The softening point of bitumen is usually determined by Ring and Ball test. Generally higher softening point indicates lower temperature susceptibility and is preferred in warm climates. The blend of different percentage of plastic waste has been prepared and their softening points were determined as given in Table-1. It is observed that the softening point increases by the addition of plastic waste to the bitumen. Higher the percentage of plastic waste added, higher is the softening point.

Table-1 Variation in softening point

% of polymer in Bitumen	Softening Point 0C		
	Polyethylene(PE)	Polypropylene(PP)	Polystyrene(PS)
0	50	50	50
0.5	52	57	53
1.0	60	62	60
1.5	62	63	61

Penetration Test (IS:1203-1978)

The penetration test determines the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. The bitumen grade is specified in terms of the penetration value. Samples having different percentage of plastic waste in bitumen were prepared and their penetration values determined as per the IS Code given in Table-2. The penetration values of the blends are decreasing depending upon the percentage of polymers and the type of polymer added. The increase in percentage of polymer decreases the penetration value. This shows that the addition of polymer increases the hardness of the bitumen.

Table-2 Variation in penetration Value

% polymer in Bitumen	Penetration value at 250C (1/10th of mm)		
	Polyethylene	Polypropylene	Polystyrene
0	70	70	70
1	68	69	69
1.5	67	68	68
2	64	64	65

Ductility

It is important that the binders form ductile thin films around the aggregate. The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks. Samples with different percentage of plastic waste in bitumen were prepared and ductility was checked. The Table-3 shows that the ductility is decreasing by the addition of plastic waste to bitumen. The decrease in the ductility value may be due to interlocking of polymer molecules with bitumen.

Table-3 Variation in ductility

% of polymer in bitumen	Ductility (cm)		
	Polyethylene	Polypropylene	Polystyrene
0	75	75	75
1	66	58	50
1.5	53	48	45
2	35	33	37

Stripping test (IS :6241-971)

The stripping is due to the fact that some aggregates have greater affinity towards water than with bituminous binders and this displacement depends on the phsico-chemical forces acting on the system. Stripping is generally experienced only with bituminous mixtures which are permeable to water.

Plastic waste was dissolved in bitumen and the blend was coated over aggregate. It was tested by immersing in water. Even after 72 hours, there was no stripping. This shows that the blend has better resistance towards water. This may be due to better binding property of the plastic waste-bitumen blend.

Flash and fire point (IS: 1209-1978)

The studies of flash and fire points of the plastic waste-bitumen blend helps to understand the inflammability nature of the blend.

Flash point "the flash point of a material is the lowest temperature at which the vapour of a substance momentarily takes fire in the form of a flash under specified condition of test."Fire point "the fire point is the temperature at which the material gets ignited and burns under specified conditions of test."Pensky –Martens closed cupapparatus or open cup are used for conducting the tests. Flash and fire point of plain bitumen is 175-210^{0}C. From the experimental results it is observed that the inflammability of the blend is decreasing as the percentage of polymer increases. The blend has developed better resistance to burning. The polymer bitumen blend road surfaces will be less affected by fire hazards.

Table-4 Variation in flash and fire point (0C)

% of polymer in bitumen	Polyethylene		Polypropylene		Polystyrene	
	Flash Point	Fire Point	Flash Point	Fire Point	Flash Point	Fire Point
0.25	280	340	320	345	240	300
0.50	290	350	330	340	270	310
0.75	295	330	333	350	280	315
1.00	340	350	342	355	295	320

results of preliminary studies

The studies of properties of the plastic waste-blended bitumen show that the addition of plastic waste to bitumen increases softening point, decreases penetration value and ductility, increases flash point and fire point, increases Marshall Stability value and improve anti-stripping properties.

b) Dry Process

An alternate method was innovated to find an effective way of using higher percentage of plastic waste in the flexible pavement. The aggregate coated with plastic was used as the raw material. The plastic used were the disposed carry bags, films, and cup etc with a maximum thickness of 60 microns. Plastic waste can be used as a coating over aggregate and this coated stone can be used for road construction. The bitumen was not blended with plastic waste.

Methodology:

Preparation of Plastic-Waste Coated Aggregate:

The aggregate was heated to around 170^0C; the plastic waste shredded to the size varying between 2.36mm and 4.75mm. This shredded plastic waste was added over hot aggregate with constant mixing to give a uniform distribution. The plastic got softened and coated over the aggregate. The hot plastic waste coated aggregate was mixed with hot bitumen 60/70 or 80/100 grade (160^0C).

Mixing by Mini Hot Mix Plant:

Step I: Plastic waste made out of PE, PP and PS cut into a size between 2.36mm and 4.75mm using shredding machine.

Step II: Similarly the bitumen is to be heated to a maximum of 160^0C to have good binding and to prevent weak bonding. (Monitoring the temperature is very important)

Step III: At the mixing chamber the shredded plastic waste is to be added to the hot aggregate. It gets coated uniformly over the aggregate within 30 Secs, giving an oily look Plastic coated aggregate is obtained.

Step IV: Hot bitumen is then added over the plastic coated aggregate and the resulting mix is used for road construction. The road laying temperature is between 110^0C to 120^0C. The roller used is 8-ton capacity.

Mixing by Central Mixing Plant (CMP):

The dry process can also be carried out using central mixing plant. The shredded plastic is added along with the aggregate in the conveyor belt. This is transferred into the hot cylinder. There aggregate is coated with plastic first and then with the bitumen. The mixer so prepared is then loaded in the dipper lorry and transported for road laying. CMP helps to have better control of temperature and better mixing of this material thus helping to have a uniform coating.

CHARACTERISTICS OF PLASTIC COATED AGGREGATE:

i. Moisture Absorption and Void Measurement:

For the flexible pavement, hot stone aggregate (170^0C)is mixed with hot bitumen (160^0C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity per IS code. The bitumen is chosen on the basis of its binding property, penetration value and viscoelastic property. The aggregate, when coated with plastics improve its quality with respect to voids, moisture absorption, soundness and other properties.

The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

ii. **Soundness Test:**

Soundness test is intended to study the resistance of aggregate to weathering action. The weight loss is attributed to the poor quality of the aggregate. The plastic coated aggregate did not show any weight loss, thus confirming the improvement in the quality of the aggregate.

iii. Porosity

The porosity of the aggregate should be less than 2%. If pores are present, the air accumulated in the pores oxidizes the bitumen and the bitumen loses its viscoelastic property. The material becomes hard. By plastic coating, the pores are very much reduced. This is evidenced by the reduction in the moisture adsorption with the percentage increase in the plastic coated. Moreover, during water stagnation; the pores accelerate the stripping of bitumen resulting in pothole formation. By coating with plastic the pores are reduced. Hence the quality of the aggregate is improved and there was no stripping of bitumen.

iv. Aggregate Impact Value

It is clearly observed that the coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate. Moreover a poor quality of aggregate can be made useful by coating with polymers

Los Angeles Abrasion Test

When the Los Angeles abrasion value of plain aggregate is compared with the Plastic coated aggregate; the values are less for polymer coated aggregate. Coating of waste plastics over aggregate will improve the Los

Angeles abrasion value. Thus we can improve the Los Angeles abrasion value of soft aggregate to a better one. Similarly the coating of plastics reduces the crushing value.

v. Stripping test

The stripping of polymer coated aggregate bitumen mix was nil even after 92 hrs whereas the non - coated showed 8% stripping even after 24 hrs.

Table–5Aggregate Qualities

Stone aggregate	% of plastic	Moisture Absorption	Soundness	Aggregate Impact Value	Aggregate crushing value	Los Angeles Abrasion Value	Voids
Without plastic coating	0	4%	5+/- 1%	25.4%	26%	37%	4%
With plastic coating	1%	2%	Nil	21.20%	21%	32%	2.2%
	2%	1.1%	Nil	18.50%	20%	29%	1%
	3%	traces	Nil	17.00%	18%	26%	Nil

Advantages & Disadvantages

Advantages:

1) Better binding property ,Higher Softening point; withstands high temp.
2) Lower penetration value; withstands higher load. No stripping – Resists the permeation of water.
3) Higher Marshall Stability–increased strength of road. Cost less compared to bitumen road.
4) Better disposal of waste plastics. Ten lakhs or one ton carry bags in one kilometre road.
5) The polymer coating also reduces the voids. This has resulted in reduced rutting , reveling, there is no formation of pot hole. The road can withstand heavy traffic & show better durability.

Disadvantages:

1) The burning of plastic waste creates air pollution and also health hazards.

Case Study:

More than 200km length plastic tar road has been laid in India at different states from 2002. These roads are functioning well without pothole, reveling and rutting. This technique was first adopted in India in 2002 in Banglore. A 25 km. plastic road was laid in Banglore. The plastic road showed superior smoothness, uniformity and less rutting as compared to a plastics - free road laid at the same time , which began developing "crocodile crack" soon after.

The process was also approved in 2003 by the CRRI (Central Road Research Institute Delhi) Road life improves through improved tackiness and viscocity of the bituminous mix , there by binding the stones more firmly together and improving the water-resistance of the mix to rain etc.

CONCLUSION:

Polymer Modified Bitumen is used due to its better performance. But in the case of higher percentage of polymer bitumen blend, the blend is a more polymer dispersion in bitumen, which get separated on cooling. This may affect the properties and quality of the blend and also the road laid using such blend.

In the modified process (dry process) plastics-waste is coated over aggregate. This helps to have better binding of bitumen with the plastic-waste coated aggregate due to increased bonding and increased area of contact between polymer and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. This has resulted in reduced rutting, ravelling, and there is not pothole formation. The road can withstand heavy traffic and show better durability

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