Plastic Roads

Use of Waste Plastic in Road Construction

Ahmed Trimbakwala

Department of Civil Engineering, K. K. Wagh Polytechnic, Nashik

Abstract- India has a road network of over 5,472,144 kilo-metres (3,400,233 mi) as on 31 March 2015, the second largest road network in the world.

The plastic wastes can be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to form plastic mats. Waste plastic is ground and made into powder; 3 to 4 % plastic is mixed with the bitumen. The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income.

I. Introduction

Plastic waste is a huge threat to the environment. In 2005, after monsoon rains flooded Mumbai, plastic bags were blamed for clogging the underground drainage system and intensifying the effect of the floods. In areas frequented by tourists, like Goa, heavy consumption of bottled water has resulted in trash on beaches, creating eyesores and endangering marine life.

Even India's cows, considered sacred, have not been spared. After 3,000 cows died in Lucknow in 2000, the city investigated and found plastic bags in their stomachs. Apparently the bags had been ingested as the animals grazed at dump sites.With more than 35 tons of plastic waste generated by every Indian state, each day India is confronted with the big question of how to get rid of this non-biodegradable menace.

II. PLASTIC AS AN ADDITIVE FOR BITUMINOUS MATERIALS

Plastic used in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to form plastic mats. The plastic roads include transition mats to ease the passage of tyres up to and down from the crossing. Both options help protect wetland haul roads from rutting by distributing the load across the surface. But the use of plastic-waste has been a concern for scientists and engineers for a quite long time. Recent studies in this direction have shown some hope in terms of using plastic-waste in road construction i.e., Plastic roads.

Plastic is mixed with the bitumen. Plastic increases the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. Use of shredded plastic waste acts as a strong "binding agent" for tar making the asphalt last long. By mixing plastic with bitumen the ability of the bitumen to withstand high temperature increases. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C. The vigorous tests at the laboratory level proved that the bituminous concrete mixes prepared using the treated bitumen binder fulfilled all the specified Marshall mix design criteria for surface course of road pavement. There was a substantial increase in Marshall Stability value of the BC mix, of the order of two to three times higher value in comparison with the untreated or ordinary bitumen. Another important observation was that the bituminous mixes prepared using the treated binder could withstand adverse soaking conditions under water for longer duration.

III. Salient Features of the Polymer-Waste-Bitumen Mix Road

- Road strength is twice stronger than normal roads;
- Resistance towards water stagnation i.e. no potholes are formed;
- Less bleeding during summer;
- Burning of plastics waste could be avoided
- It doesn't involve any extra machinery;
- It doesn't increase cost of road construction; and
- It helps to reduce the consumption of bituminous mix vis-à-vis reduce cost

IV. CONCEPT OF UTILISATION OF WASTE PLASTIC INBITUMINOUS MIXES FOR ROAD CONSTRUCTION

MATERIALS USED:-

AGGREGATE:-

Aggregates used in surface course can be divided into two types according to their size: coarse aggregates and fine aggregates. Coarse aggregates are generally defined as those retained on the 2.36 mm sieve. Fine aggregates are those that

pass through the 2.36 mm sieve and are retained on the 0.075 mm sieve. Aggregates required for the research work will be procured from the local market.

BITUMEN:-

Bitumen acts as binding agent for aggregates in bituminous mixes. Generally in India bitumen used in road construction of flexible pavement is of grades 60/70 or 80/100 penetration grade. Both the grade of bitumen confirming to BIS standards will be used for the present studies

WASTE PLASTIC MODIFIERS

Modifiers are generally used to enhance the properties of bituminous concrete mixes by reducing the air void present between the aggregates and also to bind them together so that no bleeding of bitumen will occur. For the present study plastic waste such as carry bags, water bottles, milk packets, glasses, cups, etc will be used as a modifier.

PROCESSING DETAILS:-

i. collection of waste plastic
ii. cleaning and shredding of waste plastic.
iii. mixing of shredded waste plastic, aggregate and bitumen in central mixing plant.

COLLECTION OF WASTE PLASTIC:-

Waste plastic is collected from roads, garbage trucks, dumpsites or compost plants, or from school collection programs, or by purchase from rag-pickers or waste-buyers at Rs 5-6 per kg Rag-pickers

CLEANING AND SHREDDING OF WASTE PLASTIC:-

Waste plastic litter in the form of thin-film carry-bags, use-and-throw cups, PET bottles, etc. these are sorted, de-dusted, washed if necessary. Fig. cleaning process Plastic waste which is cleaned is cut into a size between 1.18mm.

MIXING OF SHREDDED WASTE PLASTIC, AGGREGATE AND BITUMIN IN CENTRAL MIXING PLANT:-

The aggregate mix is heated to 1650c (as per the HRS specification) in central mixing plant. Similarly the bitumen is to be heated up to a maximum of 160ºc. The 8% of waste plastic to the weight of bitumen are added in the conveyor belt or special mechanical device is developed which will spray the plastics inside the chamber to coat the plastics effectively. Central mixing plant helps to have better control of temperature and better mixing of this material thus helping to have a uniform coating and heated bitumen is also sprayed. Fig. central mixing plant.

LAYING OF BITUMENOUS MIX:

I. MIX DESIGN BY MARSHALL METHOD:

a) Optimum Waste Plastic Content
b) Comparison of Two Mixes
c) Volumetric properties of BC Mixes.

I. MIX DESIGN BY MARSHALL METHOD
:-MARSHALL TEST:-

Laboratory studies were carried out at the Centre for Transportation Engineering of Bangalore University on the possible use of the processed plastic bags as an additive in bituminous concrete mixes. The material used in this study was supplied by M/s KK Poly Flex (P) Ltd., Bangalore. The processed plastic was used as an additive with heated bitumen in different proportions (ranging from zero to 12 % by weight of bitumen) and mixed well by hand, to obtain the modified bitumen .The properties of the modified bitumen were compared with ordinary bitumen. It was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 % by weight. The softening point of the modified bitumen increased with the addition of plastic additive, up to 8.0 %by weight. Auto Marshall Compactor Auto Marshall tester 11

OPTIMUM WASTE PLASTIC CONTENT:

Varying percentages of waste plastic by weight of bitumen was added into the heated aggregates Marshall specimen with varying waste plastic content was tested for bulk density and stability Maximum value of stability was considered as criteria for optimum waste plastic content Studies were carried out on Bituminous mixes using 60/70 grade bitumen having average Marshall Stability Value (MSV) of 1300 kg at optimum bitumen content of 5.0 % by weight of the mix. Further studies on mixes were carried out using the modified binder obtained by the addition of varying proportions of processed plastic bags (percentage by weight of bitumen) with the conventional 80 /100 grade bitumen. The optimum modified binder content fulfilling the Marshall Mix design criteria was found to be 5.0 % by weight of the mix, consisting of 8.0 % by weight of processed plastic added to the bitumen. The average MSV of the mix using the modified binder was found to be as high as 1750 kg at this optimum binder content, resulting in about three fold increase in stability of the BC mix, which contains 4.6 % bitumen plus 8 % processed plastic by weight of bitumen, i.e.,0.4 % processed plastic by weight of the mix.

In order to evaluate the ability of the mix prepared with the above-modified bitumen to withstand adverse soaking condition under water, Marshall Stability tests were conducted after soaking in water at 60 Co for 24 hours. The average MSV of the BC mix with modified binder (using 8 % processed plastic by weight of bitumen, as above) was found to increase by about 2.6 times of the mix with ordinary bitumen. Further laboratory studies carried out on the BC mixes using this modified binder also indicated note worthy increase in fatigue life under repeated application of loads.

Dry process is recommended for isolated works.

It is recommended that the percentage of shredded waste plastic will be 8% by CRRI, while the same is specified as 10% by Dr. Vasudevan. However we can adopt 8% as the optimum plastic content for blending the bitumen in the construction of plastic roads. The details of the process are given below. Bitumen of grades 60/70 or 80/100 can be used as binder as in case of conventional method.

With Mini Hot Mix Plant

The stone aggregate mix (as per specification) is transferred to the mix cylinder where it is heated to 165^0c (as per the IRC specification) and then it is transferred to the mixing puddler(Temperature can be monitored using IR thermometer), while transferring the hot aggregate into the puddler, calculated quantity of shredded plastics is sprayed over the hot aggregate within 30seconds. The sprayed plastic films melts and gets coated over the aggregate, thus forming an oily coating.

Similarly, the bitumen is to be heated to a maximum of 160^0c in a separate chamber and kept ready (The temperature should be monitored to have good binding and to prevent weak bonding).At the mixing puddler, the hot bitumen is added over the plastic coated aggregate and the resulted mix is used for road construction. The road laying temperature is between 110^0c to 120^0c. The roller used is normal 8-ton capacity.

Economics of Road Construction :

Cost Analysis Assuming Cost of plastics waste (collection, segregation and processing) = Rs. 5 per Kg. Cost of Bitumen per drum (200 Kg) =10000 Cost of Bitumen per Kg= 50 Cost of bitumen per ton =50000 Generally roads in India are constructed in basic width of 3.75 m Consider 1 Km length road To lay 1km of road 10 tons of bitumen is required, Cost of bitumen required per Km= Rs. 5,00,000 Assuming Optimum percentage of plastic as per the test results of literature reviewed is around 10% (by % wt. of bitumen) Total quantity of bitumen required = 9 tons Total quantity of plastic waste required = 1 ton Cost of bitumen for 9 tons = Rs. 4,50,000 Cost of plastic waste = Rs. 5000 Total cost of bitumen and plastic = Rs. 4,55,000 Total savings = 5,00,000 - 4,55,000 = Rs.45,000 per Km

Comparison Between normal roads and plastic roads

The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. Roads laid with plastic waste mix are found to be better than the conventional ones. The binding property of plastic makes the road last longer besides giving added strength to withstand more loads. While a normal 'highway quality' road lasts four to five years it is claimed that plastic-bitumen roads can last up to 10 years. Rainwater will not seep through because of the plastic in the tar. So, this technology will result in lesser road repairs. And as each km of road with an average width requires over two tones of polyblend, using plastic will help reduce non-biodegradable waste. The cost of plastic road construction may be slightly higher compared to the conventional method. However, this should not deter the adoption of the technology as the benefits are much higher than the cost. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. Already, a kilometer long test-track has been tested in Karnataka using this technology. The government is keen on encouraging the setting up of small plants for mixing waste plastic and bitumen for road construction. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from all type of plastic-waste.

V. BENEFITS OF MODIFIED BINDER

- Improved resistance to surface-initiated cracking due to high binder content.
- Improved ageing and oxidation resistance.
- Improved resistance to fatigue and reflection cracking due to higher binder contents.
- Improved resistance to rutting due to higher viscosity and softening points.
- Increased night time visibility due to contrast between pavement and stripping.
- Reduced tyre noise dur to increased binder film thickness and opening textue.
- Reduced construction time on site.
- Lower pavement maintenance costs due to improved quality pavement.
- Help in managing hazardous waste.
- Eco-friendly method of construction,and helps maintaining balance of environment.

AUTHORS

First Author – Ahmed trimbakwala, D.C.E., K. K. Wagh Polytechnic, ahmed.trimbakwala@gmail.com
Second Author – Ashish Kale, M.E. Structures, K. K. wagh Polytechnic
Third Author – PrakashKadave, M.E. Structures, K. K. Wagh Polytechnic, ptkadave@kkwagh.edu.in