

Wealth from Waste: Study of Construction of Road using Plastic Waste an Innovative Practice in Waste Management

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Abstract— As we know that, plastic creates a lot of pollution in terms of solid waste; if it burns it creates abundant air pollution. We also know that, plastic is non-biodegradable. It is very essential to manage the plastic waste to save the earth, from solid plastic waste. This paper deals with the management of plastic waste, material and methods. In this study the plastic waste is reused in construction of roads. The experimentation at several institutes indicated that the waste plastic when added to hot aggregate will form fine coat of plastic over the aggregate. When this aggregate is mingled with the binder gives higher resistance to water, higher strength and far better performance over a period of time. Hence it is proposed that the use of waste plastic in construction of roads should be enhanced.

Key words: Pollution, Plastics, Roads, Strength, Resistance, Performance

I. INTRODUCTION

Most of the paved roads in our country have granular sub base and base; bituminous base and wearing courses. The past practice of providing thin wearing coat of 20 mm premix carpet with seal coat was to allow deformation in granular layers to take place once road is opened to traffic. After the layers get compacted then thick bituminous wearing course was provided. Plastic is a very versatile material. Due to the industrial revolution, and its large scale production plastic seemed to be a cheaper and effective raw material. The application of plastic plays a vital role for the economy as the sectors such as Agriculture, Automobile, Electronic, Electrical, Building Construction, Communication sector which are very important to economy of the country. According to research, Plastic is non-degradable and can last for 4500 years without degradation. There are many health hazard caused by improper disposal of plastic waste [1]. Plastics, a versatile material and a friend to common man become a problem to the environment after its use. Disposal of a variety of plastic & rubber wastes in an eco-friendly way is the thrust area of today's research [2]. Looking at the present scenario a ban on use of plastic cannot be put, but waste plastic is taking face of devil for present and future generation. But the use of waste plastics in road construction is gaining importance these days because plastic roads perform better than ordinary ones and the plastic waste considered to be a pollution menace, can find its use. Use of waste plastic for coating found to be improving the performance characteristics of aggregate of bituminous mix. Recycle polythene carry bags are carve into small sizes and at specified temperature is coated on aggregates of the mix. Bituminous mixes were prepared with 60/70 bitumen and plastic coated aggregates/ordinary aggregates with cement as a filler material [3]. The use of plastic waste offers improvement in abrasion and slips resistance of flexible pavement and also helps to obtain the values of splitting tensile strength which satisfy limits while plastic waste

content is beyond 30% by weight of mix. If the consistent mixing time and mixing temperature are not provided for bitumen– modifier mix, modified bitumen cannot exhibit good performance in situ, thus premature failures will occur. Therefore, there are certain recommended mixing time, mixing temperature and modifier content for all the polymers with a trademark. This all should be taken in mind while mixing and lying of roads is to be done using plastic waste. Plastic road would be a boon for India. In hot and extremely humid climate durable and eco-friendly plastic roads are of greatest advantages. This will also help in relieving the earth from all type of plastic waste [4].

II. MATERIALS AND METHODS

A. Basic Process

Firstly the waste plastic is made into powder and 3 to 4% of plastic is mixed with bitumen. Plastic increases the melting point of the bitumen and makes the road retain its flexibility during winters resulting in its long life. Small pieces of plastic waste acts as a strong “binding agent” for tar making the roads 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 318.65K but when plastic is mixed, it remains stable even at 328.15K. 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. It was also observed that there was good withstand with adverse soaking conditions under water for long duration when the bituminous mix was prepared using the treated binder [11].

B. Mixing Procedure at Hot Mix Plant

- 1) Step 1: Plastics waste like bags, bottles made out of PE and PP cut into a size between 0.236 cm and 0.475 cm using shredding machine. Care should be taken that PVC waste should be eliminated before it proceeds into next process.
- 2) Step 2: The aggregate mix is heated to 438.15 K and then it is transferred to mixing chamber. Similarly the bitumen is to be heated up to a maximum of 433.15K. This is done so as to obtain a good binding and to prevent weak bonding. During this process monitoring the temperature is very important.
- 3) Step 3: At the mixing chamber, the hot aggregate is mixed with the small pieces of plastic waste. Within 30 to 45 seconds it get coated uniformly over the aggregate. It gives an oily coated look to the aggregate.

- 4) Step 4: Hot bitumen is mixed with plastic coated aggregate. Then this final resulted mix is used for laying roads. The road laying temperature is between 383.15K to 393.15K. The roller used should be of is 8-ton capacity.

III. PREPARATION OF PLASTIC COATED AGGREGATE

The aggregate is heated to around 443.15K; the plastic waste is shredded to the size varying between 2.36mm and 4.75mm. This torned off plastic-waste is 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 is mixed with the hot bitumen 60/70 or 80/100 grade (433.15K) [8].

A. Characterization of Plastic Coated Aggregate Bitumen Mix

- 1) Stripping Test (IS: 6241-1971): The plastic waste coated aggregate bitumen mix prepared by the above process was dipped in water. Even after 96 hours there was no stripping. This indicates that the plastic waste coated aggregate bitumen mix has better resistance towards water.
- 2) Marshall Stability Test: It is observed that the Marshall Stability values obtained for were generally much higher than the Marshall Stability value obtained for pure bitumen.
- 3) Field study: Using this dry process technique, road length of more than 1200 km were laid at different places in Tamil Nadu both by the department of Rural Development Agency and by Highways at Cochin, Mumbai, and Pondicherry the corporation laid test roads using this technology. The roads are exposed to heavy traffic, monsoonal change, heavy rain, hot summer etc. The roads are functioning well without potholes, raveling and rutting.
- 4) Water absorption test: A known quantity of aggregate was taken dried at 383.15K and cooled. The weight of

aggregate was determined. It was then immersed in water for 24 hrs. Then the aggregate was dried using dry clothes and the weight was determined. The water absorbed by the aggregate was determined from weight difference. 500gms of the aggregate was taken and heated to around 443.15K. It was then covered with plastic at that temperature, then the temperature of plastic coated aggregate was reduced to room temperature. It was immersed in water for 24 hrs. Then it was removed dried and the weight of the aggregate was determined. It is observed that the absorption of water had decreased with the increase in the percentage coating of plastic over the aggregate. This shows that the coating of plastic reduces the voids. Hence, coating of plastic over aggregate helps to improve the quality of the aggregate.

B. Material Cost Comparison for 1Km Road

Paving the road with by used waste plastic waste that has been successfully carried out in many areas, such as Kalamassery in Kerala and in Kolkata and Bangalore. The first technology approach, developed by Bangalore-based K K Plastic Waste Management Limited, entails using plastic waste along with bitumen – the ingredient conventionally used to make roads [6]. Not only does the road become a receptacle for plastic waste, but it also has a better grip. This dry process helps to use good quantity of plastic waste in road construction. A model calculation is given in Table 1. A model is being worked using Tirunelveli, a town in Tamil Nadu. The plastics waste collected is around 650 tonnes/ annum. The roads available are approximately 400km and their annual requirement of plastic waste to lay plastic road is more than 600 tons. So the total waste generated could be used for road laying. The life of the road is increased and hence the maintenance expenditure is reduced [9].

Size of the road	Bitumen needed	Plastic Needed	Bitumen saved	Cost Reduced
1Km×3.75	9 tonnes	1 tonnes	1 tonnes	15,000

Table 1: Comparison of Cost

Stone Aggregate	% of Plastic	Aggregate impact value (IS 2386 (part IV)-1963)%			Los Angeles Abrasion Test (IS 2386 (part IV)-1963)%			Aggregate Crushing Value (IS 2386 (part IV)-1963)%		
		PP	LDPE	HDPE	PP	LDPE	HDPE	PP	LDPE	HDPE
Without Plastic	0	23.7			22.24			24.5		
With Plastic	1	19.5	17.9	18.2	18.5	16.6	20.4	23.4	20.1	21.5
	2	15.3	14.1	12.42	17.4	14	16.3	18.5	13.5	17.4
	3	10.2	9.7	8.4	16.4	12.2	11.4	15.6	11.7	13.2

Table 2: Shows the properties of natural and plastic coated aggregates used for construction of roads [7]

IV. SALIENT FEATURE OF ROAD

In India more than 4.25 million Km of road is available. If this technique is used for constructing or repairing of road, then there will be large amount of plastic is used. The process is eco-friendly. Segregating plastic from the MSW at municipal yard involves application of resources, the cost of which runs into crore of rupees. A substantial amount of this can be saved. Researches and real time test says that the life of plastic road is at least 100% more than normal road. This technique adds a cumulative benefit to National Economy also gives contribution to environmental benefits, employment generation and agricultural efficiency [10]. Some of the roads in Delhi region made with plastic waste.

- Stronger road with increased Marshall Stability value.
- Better resistance towards rain water and water stagnation so no stripping and no potholes.
- Less rutting a raveling because of increase binding and also better bonding which results in reduction in pores in aggregate.
- No leaching of plastics. No effect of radiation like UV.
- The load withstanding property increases. It helps to satisfy today's need of increased road transport.
- Value addition to the waste plastics (cost per kg. increases from Rs. 4 to Rs. 12).
- The cost of road construction is also decreased and the maintenance cost is almost nil. As road pavement life is

doubled when we use this novel technique for road construction, we have to pay only Rs. 25000/- more, instead of spending Rs. 10,80,000/- for its up gradation in just 2-3 years, thus saving Rs.10,50,000/- per Km.

V. CONCLUSION

The issues highlighted above throw light on the urgent needs for re-examining and formulating new guidelines/specification with regard to design and construction of concrete roads in India. The issues raised become more pertinent in the context of the large scale construction of cement concrete roads at the anvil. Feedback from the various construction agencies and from research and development fraternity can lead to meaningful contribution in solving many issues at stake in the field of design and construction of concrete roads in India. 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. Therefore the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics.

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