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# PLASTIC WASTE SHREDDED BITUMEN ROAD

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**Abstract: - Plastic waste can be utilized in the road construction. The field test had proved that after proper processing of plastic waste it can be used as an additive that can enhance life of roads and solve environmental waste plastic disposal problems. It is retrieved from the on field result that road strength had increased twice than normal roads, construction process does not involve additional machinery, cost of construction is reduced and consumption of bitumen in road construction is reduced by utilizing plastic waste in construction process. Since bitumen is good binder, so bitumen and waste plastic can be mix and use as a top layer of flexible pavement. The waste plastic is shredded and coated over aggregate and mixed with hot bitumen and the resulted mix is used for pavement construction. This modified mix had showed better binding property, density, stability and more resistant to water. We cannot completely ban use of plastic but we can reuse plastic waste. This plastic waste partially replaced the conventional material to improve desired mechanical characteristics for road mix. In this paper, developed techniques to use plastic waste for construction of roads has reviewed.**

**Keywords:-** *Plastic Waste, Aggregate, bitumen, Polymer coated aggregate, Flexible Pavement.*

## I INTRODUCTION

This invention relates to a method of producing a road making material and a road made therefrom. As more than 35 tons of plastic waste is generated by Indian states daily so this had raised a big question of its disposal and handling. Attempts of recycling of plastic waste is unsuccessful is expensive too and burning this waste had released hazardous gases to the atmosphere. The most important developing indication of any nation is the growth and quality of infrastructure. Roads, bridges, dams, tunnels, etc. comes under the various sectors of infrastructure. In any nation, construction of roads is the major part of infrastructure than other sectors of infrastructure because road construction is the most convenient and basic mode of transportation.

Environment is also the important point of concern for any country like its infrastructure to make better place for any habitat to live in. In a highway, the potholes and corrugation is major problem. Plastic pavements will give better solution to such problems. The invention seeks to utilize waste plastic material, although it is to be understood that the benefit of the method of this invention is not dependent upon such use, since other sources of plastic may be utilized. Primarily, this invention seeks to produce an improve road making material and an improved road produced therefrom. By this research work, a balance can be maintained between two factors i.e environment and infrastructure which governs to reduce the overall road construction cost of any project and progress of that nation.

## II PLASTIC WASTE SCENARIO

Plastics can be classified according to their physical properties and chemical sources. As per the classification by chemical sources the twenty or more known basic types falls into four groups: Elastomers, Fibers, Natural resin, Synthetic resin, Cellulose plastic and Protein plastic. According to physical properties plastic are classified as thermoplastic and thermosetting material. Under heat and pressure thermoplastic materials can take any desired shape and become solid on cooling. Thermosetting materials once shaped cannot be again reshaped on application of heat. From the total post-consumer plastic waste generated, 80% are constitutes of thermoplastics and 20% are constitutes of thermosetting plastic material.

In India in an average 0.21 to 0.50 kg per capita per day municipal solid waste is generated. At

temperature between 130-140◦C, most of the thermoplastic soften on heating. As per TGA analysis, in the temperature range 130-180◦C there is no gas evolution from thermoplastic and beyond 180◦C gas is evolved with thermal degradation. As the temperature at mixing of bitumen and plastic is nearby same so it is easy to use plastic waste in bending with bitumen for road construction process.

## III MANUFACTURING OF BITUMINOUS ROAD USING PLASTIC WASTE.

### A] Basic Process:

Plastic is grounded to form powder and then 8 to 10% plastic to the weight of bitumen is added along with bitumen. Melting point of bitumen is increased due to addition of plastic due to which road retain its flexibility. The asphalt last long as shredded plastic waste is strong binding agent for tar. The bitumen can withstand high temperature due to mixing of plastic and bitumen. A particular ratio is maintained while mixing melted plastic with bitumen. Normally, blending takes place at 45.5◦C and also remains stable at 55◦C after mixing plastic. For surface course of road pavement, bituminous concrete mixes prepared by using treated bitumen binder fulfilled all Marshal mix design criteria. There was two to three times increment in the order for Marshal stability value in comparison with untreated or ordinary bitumen mix. Bituminous mixes prepared from treated binder can survive adverse soaking condition by absorbing water for longer duration.

### B] Interaction of Bitumen, Plastic and Aggregate:

The shredded plastic melted on spraying over hot aggregate and this spraying gave a thin coating at the surface. At 140℃ to 160℃ aggregate temperature the plastic is in softened state. On the above plastic aggregate mix bitumen having temperature of 160℃ is added. Bitumen get spreads over the aggregate and plastic coated mix. At 160℃ temperature there is easy diffusion at the interphase of coated plastic and bitumen which are in liquid state. Increased surface contact area of the above components had eased the further process. Poly ethylene [PE], poly propylene [PP], poly styrene [PS] are the waste polymers and bitumen are the complex mixture of asphaltenes and maltenes. At the intermixture of bitumen and plastic coated aggregate, a portion of bitumen diffuses through plastic layer and binds with aggregate. There is already set up bond between plastic layer and aggregate. In between the polymer molecule and bitumen a three dimensional internal cross linked network structure is formed. So the removal of bonded bitumen becomes difficult as stronger bond is formed between them.

### C] Hot Mix Plant mixing procedure:

**Step I:** By utilizing shredding machine bags, bottles made from PP and PE plastic are cut into a size between 2.36mm and 4.75mm. One should take care to prevent mixing of poly vinyl chloride [PVC] waste along with other plastic waste.

**Step II:** After heating aggregate mix at 165℃ it is then transferred to mixing chamber. To prevent weak bonding and to obtain good binding even bitumen is heated at 160℃. During mixing it is important to monitor temperature.

**Step III:** The shredded plastic waste is added over hot aggregate at mixing chamber. The plastic coating gives oily look to aggregate as it gets coated on aggregate within 30 to 45 sec. Step IV: Then the above mix of aggregate and plastic is added with bitumen. The mix formed from all three components is ready for laying on roads. The temperature of 110℃ to 120℃ should be maintained at the time of laying and a roller of 8 ton capacity should be used.

## IV COMPARISON BETWEEN PLASTIC MIXES AND ORDINARY MIXES

1] Roads made from shredded plastic waste are durable as compared to roads of ordinary mixes. The life of roads laid out of plastic waste mix is about 10 years than the normal 4 to 5 years life of conventional ones.

2] Plastic has good binding property helping to increment the life of roads and gives additional strength to withstand more loads. So plastic waste mix roads better than conventional ones.

3] Less road repairs as rainwater will not seep as plastic is present in tar.

4] Non-biodegradable waste will be reduce as two ton of polybend plastic is required for formation of 1km of road having average width.

5] As compare to conventional method cost, this method may cost slightly more. But we should not regret the

implementation of this technology as benefits are more than cost.

6] Plastic roads can withstand extreme climatic temperature prevailing in India and survive rainfall havoc floods.

## V COST COMPARISON FOR 1KM LENGTH OF ROAD.

For construction of 1km length of road having base width of 3.75m,

1] Assuming cost of collection, segregation and processing of plastic waste = Rs 5 per kg.

2] Cost of bitumen = Rs 50 per kg

3] Cost of Bitumen = Rs 500000 per km

4] Quantity of plastic waste = 1ton per km

5] Quantity of bitumen = 4 ton per km

6] Cost of 9 ton bitumen = Rs 450000

7] Cost of 1ton of plastic = Rs 5000.

8] Total cost of bitumen mix plastic = Rs 455000

9] Difference in cost of both pavements = 500000-455000 = Rs 45000 per km.

The amount of raw material used for 25mm SDBC 3750 mˆ2 road has saved 1ton of bitumen costing Rs 50000. The maintainance cost of the road is reduced as this roads can withstand without maintenance for 7 years. Utilization of plastic in road making process can saved atmospheric pollution by preventing the emission of carbon dioxide from incineration of waste plastic.

## VI INTERPRETATION OF RESULTS FOR PLASTIC COATED AGGREGATE BITUMEN MIX.

### A. Extraction Characteristics

The bonding nature of bitumen with the PCA [polymer coated aggregate] was clearly explained from experimental results of extraction of bitumen from the PCA bitumen mix. Bitumen can be removed by TCE [tri chloro ethylene] from plain bitumen coated aggregate whereas removal of bitumen by TCE is a slow process and is partial only in case of PCA bitumen mix. Both plastic and bitumen can be removed on further treatment by decaline, an organic solvent. Complete removal from the mix is possible by refluxing decaline for more than 30 min with the PCA bitumen mix.

The extraction test has the following results. The TCE can remove only loosely bonded bitumen and could not remove the bitumen bonded with aggregate through plastic. The organic solvent decaline can break the bond between plastic and bitumen only after refluxing. The extent of bitumen removal was correspondingly less if the percentage of coating of plastics was more. This concludes that bonding of bitumen over PCA is strong.

### B. Marshall Stability Value [MSV]

For plain aggregate bituminous mixes and PCA bituminous mixes Marshall Stability Value [kN], flow value [mm] and Marshall quotient [kN/mm] were obtained. The range of flow values should within 2 to 5 and ratio of MSV and flow value should not be greater than 500 for an effective asphalt pavement. The results obtained are within this range for PCA. Voids filled with bitumen are expected upto 65% and the observed value is 58 % only. The reduction is attributed to reduce utilization of percentage of bitumen and reduction of voids. The quantity of bitumen required for good mix is reduced by 0.5% of total weight of the mix only by the use of plastic waste in coating aggregate. This reduces the use of bitumen in mixes by 10%. This is good saving of natural source. The following observations were noted in the test:

1] The MSV of mix is increased by the use of PCA.

2] The MSV is also increased by increment in the percent coating of waste plastic.

3] More than 15% plastic coating results in lesser compatibility and lesser bonding with bitumen and in lower MSV.

4] Higher MSV is obtained by use of PP instead of PE.

5] The mathematical modeling arrived at optimum percent of plastic coating result and the optimum percent of plastic was 10% of the bitumen used.

6] The MSV values were compared with PMB [polymer modified bitumen ] mix and PCA [polymer coated aggregate] mix. The PCA bitumen mix has 50 to 60% higher value than PMB mix resulting in higher binding strength for PCA bitumen mix.

**C.Stripping Value**

The polymer gets coated on the aggregate by forming polymer film and there are no pores left. Moreover, at the time of coating polymer also fills all the pores present in the aggregate and forms organic bonding by strongly binding with bitumen. The PCA bitumen mix has a better stripping value as water cannot penetrate over PCA and peeling of bitumen is nil from PCA mix even after 96 hrs.

**D. Reduction of carbon dioxide emission**

Burning of littered plastics along with domestic waste can produce green house gases resulting in global warming. Waste plastic are softened to use them as coating material in dry process and not burnt. As 1ton of plastic is used in laying 1km single lane road, such use reduces the emission of carbon dioxide to the tune of 3 tons which could otherwise be produced if plastic was burnt. The plastic bitumen road are laid at various places in India for about 2500km by using this technology. So this prevented burning of 2500 tons of plastic waste and due to which 7500 tons of carbon dioxide emission is prevented.

## VII CHARACTERISTICS OF PLASTIC COATED AGGREGATE FOR FLEXIBLE PAVEMENT

**A. Void Measurement and Moisture Absorption**

The mix of hot stone aggregate and hot bitumen is used in flexible pavement for road laying. On basis of strength, porosity and moisture absorption capacity the aggregates are chosen as per IS coding. On basis of binding property, penetration value and viscoelastic property bitumen is chosen. The coating of plastic upon aggregate improves its quality with respect to voids, soundness and moisture absorption. Porosity of aggregate is decreased by coating plastic on it and so the quality and performance of aggregate is improved in the flexible pavement. The stones with <2% are only allowed by the specification.

**B. Soundness Test**

The aim of this test is to study the resistance by aggregate to weathering action. The weight loss of aggregate by weathering attributes to its poor quality. But the plastic coated aggregate does not undergoes any weight loss showing the improvement in the aggregate quality.

**C. Los Angel's Abrasion Test**

The surface of pavement has to undergo some wear and tear due to repeated movement of heavy vehicle. The percentage of wear and tear is determined by this test study. The test results revealed that the plastic coated aggregate are subjected to less percentage of wear and tear. The percent of wear and tear reduces with respect to the percent of plastics. On comparison with plain aggregate the values of plastic coated aggregates are less.

**D.Softening Point Test**

It is the temperature at which a particular degree of softening is attained by the substance on subjecting to heat. This test is conducted by ring and ball apparatus. If the substance have higher softening point then it means that it has lower susceptibility and can withstand hot climate. The softening point bitumen which is replaced by plastic is higher thus making it suitable to use in hot regions.

**E. Penetration Test**

This test is used to determine hardness of the bitumen. This test is performed using penetrometer. The results are evaluated by the penetration distance of a standard needle into the bitumen. The distance is measured in millimeter for 5 secs at 25℃ temperature using 100grm load. Higher the penetration the softer is the bitumen. The bitumen having additive as plastic is having lower penetration values indicating its suitability of hardness.

## VIII CASE STUDIES IN INDIA

Laboratory studies were carried out at Banglore University Transportation Engineering Centre. The results revealed from such investigations that plastic can be used as an additive in road construction process. The addition of 8 to 10% plastic by weight of bitumen resulted in saving of bitumen by 0.4 to 0.5% of weight of mix. This test is used to determine hardness of the bitumen. In Tamil Nadu, under 1000km Plastic Tar Road Scheme, around 1000m length of roads were constructed in various stretches and the performance of all the road was satisfactory. Similarly, this roads were constructed in Karnataka and their performance was also satisfactory. The construction of roads in the above state was carried out under the guidance of Banglore

University, CRRI [Central Road Research Institute] and College of Engineering Madurai.

## IX CONCLUSION

Formulation and re-examination of guidelines and specification is necessary with regards to design and construction of roads in India in order to throw lights on the above highlighted issues. In the context of large scale construction of roads the above issues become more pertinent. For Flexible pavement construction, the PCA bitumen mix are better material. Hence, using waste plastic for flexible pavement is one of the best method for easy waste plastic disposal. Thus, the process gives better infrastructure and are socially highly relevant. We can conclude that this technology had avoided the disposal of plastic waste by land filling or by incineration which has ultimately become a eco-friendly technology. The life spans of roads is reducing due to increased traffic condition. Plastic roads will prevent the accumulation of solid plastic waste in the environment. Millions of dollars can be saved in future by avoiding the need to find unnecessary ways of plastic disposal and also resources can be saved to be use in the future.

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