

Use of Plastic Waste in Construction of Flexible Pavement: A Creative Waste Management Idea

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Abstract— The amount of plastic waste is escalating due to population increase. Disposal is hazardous and that’s why it has become a serious problem. Because of increasing traffic intensity, the load bearing capacity has to be paralleled these problem can be solved by using plastic waste in flexible pavement. This waste comprising of carry bags, polymers, cups etc. can be utilized for coating over aggregate in pavement construction. For construction of 1 km length and 3.75 meter width of single lane pavement, 10,00,000 plastic carry bags have to be used which increases strength by 100% and no potholes can be found. The distresses such as rutting, fatigue cracking and temperature cracking affect the pavement performance so plastic has to be used with bitumen as binder to increase strength, stability, durability and water resistant. The main aim of paper is to analyze and study the utilization of plastic waste in flexible pavement construction as a binder to replace the content of bitumen.

Keywords: - Plastic Waste, Aggregate, Bitumen, Flexible Pavement.

I. INTRODUCTION

There are two types of pavements rigid pavements and flexible pavements. Concrete is used for rigid pavements while bitumen is used for flexible pavements. Flexible pavements are very important in today’s infrastructure. Future scenario of countries will be affected by traffic damage. Bituminous binders are causing bleeding in hot climate, cracks in cold climate, rutting, pot holes and its water resistance is poor. Any improvement in quality of binder is needed. Several studies have shown that improper disposal of plastic waste causes health hazards. Various types of plastic waste are non-biodegradable thus they can be used as bitumen modifier and aggregates to increase their strength.[5] It performs better than normal roads. Every important sector of economy has been revolutionized by application of plastics. The uses of plastic waste improve abrasion and slip resistance of flexible pavement. This concept of utilization of waste plastic in bituminous mixes for road construction has been done since 2000 in India.

II. GENERATION, CONSUMPTION & CLASSIFICATION OF PLASTIC WASTE IN INDIA

India generates 5.6 million metric tons plastic waste annually and only Delhi generates 689.5 tons every day, Central Pollution Control Board (CPCB) report says.

Table 1: Plastic waste consumption in India

Sr. No.	Year	Consumption In Tonnes
1.	1996	61000
2.	2001	400000
3.	2006	700000
4.	2011	1350000
5.	2013	1740000

Table 2: Municipal solid waste in Indian cities.

Population Range (Millions)	Average per capita value
0.1-0.5	0.21
0.5-1.0	0.25
1.0-2.0	0.27
2.0-5.0	0.35
> 5	0.50

The plastic is of two types :- a) Thermoplastic

b) Thermosetting

Table 3: Types of plastics.

Sr.No.	Thermoplastic	Thermosetting
1.	Polyethylene Teryphthalate	Bakelite
2.	Polypropylene	Epoxy
3.	Polyvinyl Acetate	Melamine
4.	Polyvinyl Chloride	Polyester
5.	Polystyrene	Polyurethane

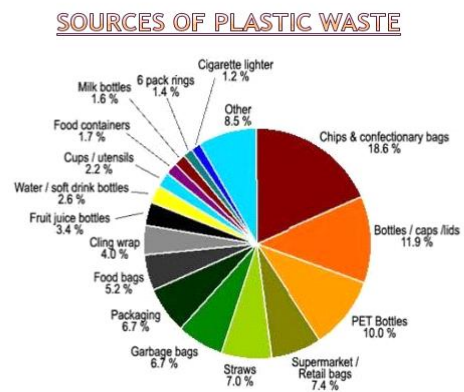


Figure 1: Plastic waste sources

III. METHODOLOGY

A. Basic Process

Firstly, plastic waste is grounded & converted into powder form; now 3 - 4 % plastic is mixed with bitumen. The melting point of bitumen is increased by using plastic, thus during winter season flexibility is preserved. Shredded plastic works as strong binding material for tar forming the asphalt for lifetime. The ability of bitumen to withstand higher temperatures can be increased by mixing plastic with bitumen. The ratio of melted and mixed plastic with bitumen is particular. Blending occurs when temperature reaches 45.5°C but when plastic is mixed; it remains at 55°C. The test proves that bitumen concrete mixes made from treated bitumen binder fulfilled every Marshall Mix design criteria for road pavement. Another observation is that it can withstand adverse soaking condition for higher duration.[3]

The shredded plastic is to spray over the hot aggregate is melted and spreaded over the aggregate; it gives a thin coating at surface of aggregate. At 140 - 160°C temperature, the coated plastic stays in the softened state, in the next process; hot bitumen (160°C) is added. The aggregates are spreaded over added bitumen. Both the coated plastic sand bitumen is in liquid state at this temperature & capable of easy diffusion at interface. In the further process the contact area is increased. Bitumen is a complex mixture of asphaltenes & maltenes which are long chain hydrocarbon. During the mixing of bitumen with plastic coated aggregate, some part of bitumen diffuses through the plastic layer and binds with aggregate. The plastic layer has bonded with aggregate. During this process, a 3-D internal cross linked network structure is formed between polymer molecules and bitumen constitutes. Thus bond becomes stronger and removal of bonded bitumen becomes difficult.[4]

B. Mixing procedure at hot mix plant

- Plastics waste (cups, bags) made out of PE, PP and PS cut into a size between 2.36mm and 4.75mm.
- The aggregate mix is heated to 165°C (as per the HRS specification) and transferred to mixing chamber.
- Similarly the bitumen is to be heated upto a maximum of 160°C (HRS Specification) to have good binding and to prevent weak bonding.
- Shredded plastic is added to the hot mix. The plastic gets softened and coated over the surface of the aggregate giving an oily look in 30 - 60 sec.
- Waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The road laying temperature is between 110°C to 140°C. The roller used is 8-ton capacity.

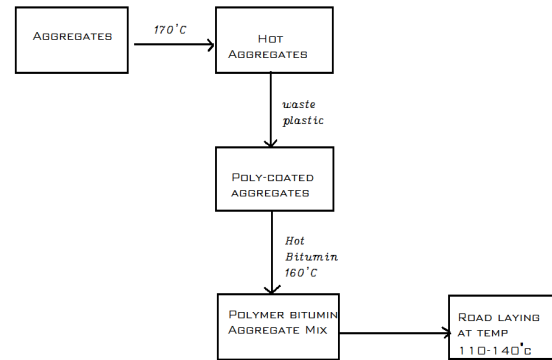


Figure 2: Flowchart of plastic coated bitumen road

C. Process for manufacturing bitumen mix road using plastic waste

There are two following processes-

• Dry process

In this process, the burning of plastic is not performed and coating is done by softening of plastic waste. The mix for road laying is prepared by mixing of hot aggregate (170°C) and hot bitumen (160°C).

• Wet process

The plastic waste [1] is ground and made into powder 6 to 8%. Plastic is added to the bitumen at 160°C. The process did not yield a homogenous mix with prominent separated solid deposits of mix therefore wet process was not adopted and another waste material (crumb rubber) has been adopted to add to it.

IV. RESULT & DISCUSSION

Thus by following methodology flexible pavement using waste plastic are constructed. Further on performing laboratory tests aggregate impact value, aggregate crushing value, specific gravity, stripping value, water absorption etc. are to be found.

Discussion can be easily understood by comparing plastic waste flexible pavement in cost and features to the normal flexible pavements.

A. Cost comparison

The cost difference for the roads laid with compound as against without it is Rs. 500 / Cubic Meter. Saving of 8% by weight of bitumen. Increase in compressive strength. Indirect tensile strength values increased by 3 times. Provide smooth riding surface displaying much better durability. This initiative demonstrates scalability of the project and a win-win situation for both constructions of roads and handling of waste plastic bags.[2]

V. CONCLUSIONS

It shows that with the increase of waste plastic in bitumen increases the properties of aggregate and bitumen. Use of waste plastic in flexible pavements shows good result when compared with conventional flexible pavements. This

has added more value in minimizing the disposal of plastic waste as an eco-friendly technique. Coating of polymer on the surface of the aggregate has resulted in many advantages, which ultimately helps to improve the quality of flexible pavement.

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