

Construction of plastic roads: An effective way to utilize wastes

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Abstract – The population growth, industrialization, consumerism and technological development have led to uncontrollable accumulation of waste. Proper waste disposal is of great importance in both rural and urban areas, as it increases environmental pollution and occupies land around industrial plants. One of the solutions is to use these recycled materials in pavement construction. Today the majority of roads are constructed using bitumen, tar or cement. Another kind of road has been suggested: Plastic road. This provides a solution to the problem of effective disposal of plastic waste at the same time increases the strength and durability of the road, addresses the environmental, economic and most importantly safety issue.

1. INTRODUCTION

Plastic products have become an indispensable part of our daily lives as many objects of daily use are meant from some kind of plastic. The growth in various types of industries together with population growth has resulted in enormous increase in production of various types of waste materials world over. Plastic is everywhere in today's lifestyle. It is used for packaging, protecting, serving and even disposing of all kinds of consumer goods. With the industrial revolution mass production of goods started and plastic seemed to be a cheaper and effective raw material. Use of this non-biodegradable product is growing rapidly and creating problem of disposal of plastic waste. Disposal of plastic waste is particularly plastic bag menace and has become a serious problem especially in urban areas in terms of its misuse, its dumping in the dustbin, clogging of drains; reduce soil fertility and aesthetic problems, etc. The risk to the family health and safety would increase and above all the environmental burden would be manifold. Hence, it is needed that plastic product must be recycled and not end in landfills. Hence, one is the way of disposing tyre waste as crumb rubber into the road for modification of bitumen. Proper addition of such waste in bitumen improves quality, life and minimizes construction cost of road.



Figure-1: Plastic-bitumen road

1.1 Problems with Disposal of Plastic Waste

Disposal of plastic waste has emerged as an important environmental challenge and its recycling is facing roadblocks due to non-degradable nature. Because plastic does not decompose biologically, the amount of plastic waste in our surroundings is steadily increasing. Plastic waste is often the most objectionable kind of litter and will be visible for months in landfill sites without degrading.

The primary methods employed for the disposal of plastic wastes are:

- (i) **Incineration:** Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration of waste materials converts the waste into ash, flue gas, and heat.



Figure-2: Incineration

- (ii) **Land filling:** The Landfill Directive defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land.



Figure-3: Land filling

1.2 Methodology

Waste plastic is made powder and varying percent plastic is mixed with bitumen. Plastic increase the melting point of the bitumen and makes the road flexible during winters resulting in its long life. By mixing plastic with bitumen the brittleness overcomes and elastic nature enhances. The plastic waste is melted and mixed with bitumen in a particular ratio. There are two important processes used for bitumen mix flexible pavement, they are

- (i) Dry process
- (ii) Wet process

(i) Dry Process:

For the flexible pavement, hot stone aggregate (170°C) is mixed with hot bitumen (160°C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding property, penetration value and viscous-elastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness.

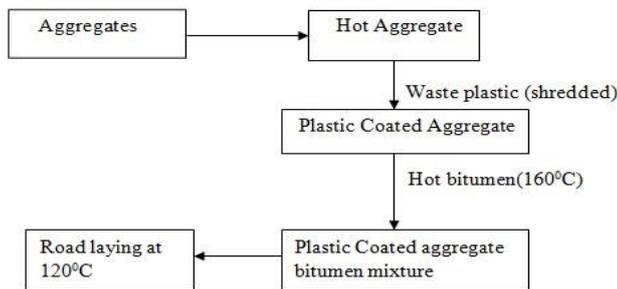


Figure-4: Flow chart of dry process

In this process the shredded plastics are poured over the heated aggregates, thus forming plastic coated aggregates which are then mixed with hot bitumen to form plastic coated aggregate bitumen mixture for laying roads. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

(ii) Wet Process:

These are the method used for formation of polymer based modified bitumen, in which the waste polymer directly added with bitumen and heated upto temperature of 170°C so that proper blend is to be formed with proper dispersion of waste polymer into bitumen, then the hot mix is then cooled upto 120°C into another chamber, which is then added to the aggregate in paddling chamber. The mix is to be cooled because when hot mix poured on aggregate then there are chances to form air pocket into small gap of

aggregate and chances in lower the strength of rods and chances of rutting of roads. After addition of modified bitumen at 110°C on aggregate, it is then laid on the road and then spreader material is compacted by 8 ton roller.

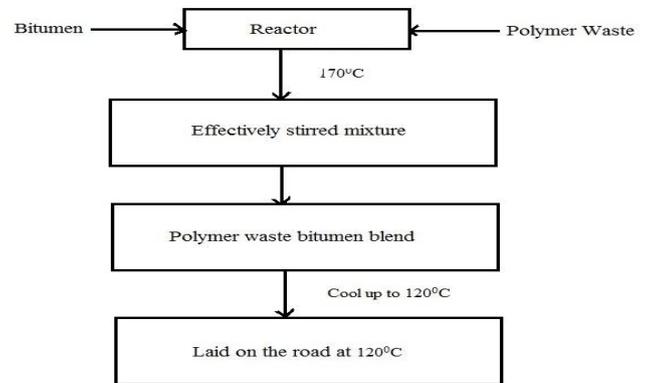


Figure-5: Flow chart for wet process

2. RESULT

The results of the studies on the extraction of bitumen by dry process showed that the bonding between stone aggregate and bitumen is improved due to the presence of polymers. This may be explained by the following tables.

Table-1: Bitumen Extraction at certain Interval

Plastic Content (% By Weight)	Bitumen Extracted After 5 Min %	Bitumen Extracted after 10 min %	Bitumen Extracted after 15 min %
0	95.0	97.0	98.0
0.5	63.0	87.9	92.3
0.75	62.7	85.3	90.7
1.0	60.6	76.2	82.8

Use of higher percentage of plastic waste reduces the need of bitumen by 10-12%. It also increases the strength and performance of the road.

Table-2: Improved Characteristics of plastic coated aggregate

% of Plastics	Moisture Absorption	Soundness	Voids	Aggregate Crushing Test
Nil	4%	6%	4%	24%
1%	1%	Nil	2.2%	19.5%
2%	1%	Nil	1%	18%
3%	0.5%	Nil	Nil	NA
5%	0.32%	Nil	Nil	NA
10%	0.15%	Nil	Nil	NA

Note: The above value shows that the plastic coated aggregate shows improved quality which is responsible for the better performance of the road.

3. CONCLUSIONS

Polymer Modified Bitumen is used due to its better performance. 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, raveling, and there is no pothole formation. The road can withstand heavy traffic and show better durability. The use of the innovative technology will not only strengthen the road construction but will also increase the road life as well as help to improve the environment and will also create a source of income.

Future Scope of Bitumen Roads:

The main scopes of plastic roads are:

- (i) **Economic in terms of bitumen:** The shredded plastic in form of polymer covers the aggregates and thus occupies a larger portion of the road reducing the quantity of bitumen needed.
- (ii) **Efficient management of non-biodegradable waste:** Plastic is a harmful and non-biodegradable waste responsible mainly for land pollution. Utilizing it for road construction will result in its efficient management.
- (iii) **Easy process without any new machinery:** It is a simple and easy technique which does not involve any complex or new machinery.
- (iv) **Enhanced durability:** The addition of plastic to bitumen will help in improving the strength and durability of the pavement.

A well constructed plastic bitumen road will result in the following advantages:

- Strength of the road increased (increased Marshall Stability Value)
- Better resistance to water and water stagnation
- No stripping and have no potholes in the pavement
- Increased binding and better bonding of the bitumen mix
- Increased load withstanding property of road
- Overall consumption of bitumen decreases
- Maintenance cost of the road is almost nil
- The road life period is substantially increased
- No effect of radiation like UV

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BIOGRAPHIES



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