Review Article

POTENTIAL REUSE OF PLASTIC WASTE IN ROAD CONSTRUCTION: A REVIEW

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ABSTRACT

Now-a-days Plastic is everywhere in today's lifestyle. The disposal of plastic wastes is a great problem. These are non-biodegradable product due to which these materials pose environmental pollution and problems like breast cancer, reproductive problems in humans and animals, genital abnormalities and even a decline in human sperm count and quality. In recent years, applications of plastic wastes have been considered in road construction with great interest in many developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria. Several million metric tons plastic wastes are produced in India every year. If these materials can be suitably utilized in highway road construction, the pollution and disposal problems may be partly reduced. Keeping in mind the need for bulk use of these wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of plastic wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low-volume roads in different parts of our country. A review of various plastic wastes for use in the construction of roads has been discussed in this paper.

KEYWORDS polyethylene (PE), polypropylene (PP) and polystyrene (PS), Plastic Wastes, Bitumen, Asphalt etc.

I. INTRODUCTION

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. Today, every vital sector of the economy starting from agriculture to packaging, automobile, building construction, communication or InfoTech has been virtually revolutionized by the applications of plastics. Use of this non-biodegradable (according to recent studies, plastics can stay unchanged for as long as 4500 years on earth) product is growing rapidly and the problem is what to do with plastic-waste. Studies have linked the improper disposal of plastic to problems as distant as breast cancer, reproductive problems in humans and animals, genital abnormalities and even a decline in human sperm count and quality. If a ban is put on the use of plastics on emotional grounds, the real cost would be much higher, the inconvenience much more, the chances of damage or contamination much greater. The risks to the family health and safety would increase and, above all the environmental burden would be manifold. Hence the question is not 'plastics Vs no plastics' but it is more concerned with the judicious use and re-use of plastic-waste.

In recent years, applications of plastic wastes have been considered in road construction with great interest in many developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria. The lack of traditional road materials and the protection of the environment make it imperative to investigate the possible use of these materials carefully India has a large network of metro cities located in different parts of the country and many more are planned for the near future. Several million metric tons plastic wastes are produced every year in India. Traditionally soil, stone aggregates, sand, bitumen cement etc. are used for road construction. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, and plastic wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these plastic wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low-volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement

On heating at 100-160°C, plastics such as polyethylene, polypropylene and polystyrene, soften

and exhibit good binding properties. Blending of the softened plastic with bitumen results in a mixed that is amenable for road laying. The mixed has been used to lay roads of length up to 1,500 km in the state of Maharashtra. Other states like Tamil Nadu, Karnataka, Pondicherry, Kerala and Andhra Pradesh have also laid test roads. These roads have withstood loads due to heavy traffic, rain and temperature variation

PREPARATION OF POLYMER- AGGREGATE-BITUMEN MIX

- Cleaned and dried plastic wastes (e.g.: disposed carry bags, films, cups and thermocole) with a maximum thickness of 60 microns is shredded into small pieces (2.36 mm - 4.75 mm size). PVC is not suitable for this process.
- Aggregate is heated to 165°C in a mini hot mix plant
- 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.
- Hot Bitumen (heated up to a maximum of 160°C to ensure good binding) is added immediately and the contents are mixed well.
- The mix, when cooled to 110-120°C can be used for road laying using 8 ton capacity road roller. As the plastics are heated to a maximum temperature of 165°C, there is no evolution of any gas. When heated above 270°C, the plastics get decomposed and above 750°C they get burnt to produce noxious gases.

II. ENHANCED PROPERTIES OF THE MIX

Coating of plastic over aggregate to the tune of 10-15% by weight of bitumen improves the binding properties of the mix:

- Higher softening point and lower penetration point due to interlinking of polymer molecule with bitumen.
- Lesser moisture absorptive capacity due to coating of plastics at the surface.
- Better ductility, higher Marshall Stability value.
- Better stripping value (No stripping on soaking in water for 72 hrs)
- High compressive strength (>100mpa) and high flexural strength (>450 Kg/cm with respect to the binding property)
- The roads are twice as strong as normal roads and resistant towards water stagnation and lesser bleeding during

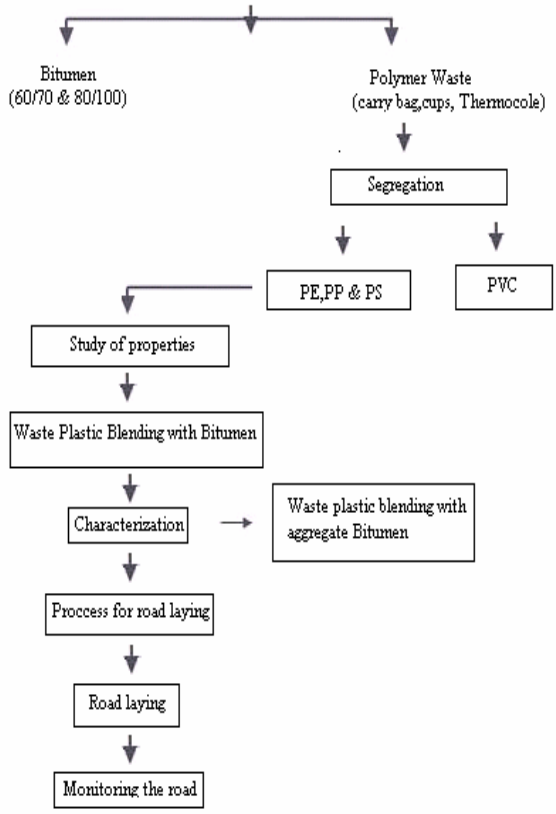
Polymer blended Bitumen shows higher Softening point, lower penetration point, and better ductility. Polymer coated aggregate blended with Bitumen shows higher Marshall value and better stripping value showing that the mix is more suited for road laying.

III. PROCESS OF ROAD LAYING USING POLYMER- AGGREGATE – BITUMEN MIX

The plastic waste (bags, cups, Thermocole) made out of PE, PP, & PS are separated, cleaned if needed and shredded to small pieces (passing through 4.35mm sieve) The aggregate (granite) is heated to 170^{o}C in the Mini hot Mix Plant and the shredded plastic waste is added, it gets softened and coated over the aggregate. Immediately the hot Bitumen (160^{o}C) is added and mixed well. As the polymer and the bitumen are is the molten state (liquid state) they get mixed and the blend is formed at surface of the aggregate. The mixture is transferred to the road and the road is laid. This technique is extended to Central Mixing Plant too.

Flow Chart showing method for construction of Road

Raw material



IV. 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

It is observed that addition of plastics waste up to 10-15% by weight of bitumen resulted into higher values of softening point and lower values of penetration, which are appreciable improvements in the properties of the binder. This has resulted and withstood higher traffic load and high temperature variation. Several experimental stretches have been laid in more than 15 locations in Tamilnadu using both Mini hot-mix and central mixing plants.

V. ECONOMICS OF ROAD CONSTRUCTION.

A. Laying of bitumen road – Indian Roads Congress (IRC) Specifications

There are different types of bitumen roads. They are, Dense Bituminous Macadam, Bituminous Macadam. These roads differ in 3-ways i.e. 1. Composition of the aggregate; 2. Type of bitumen used; and 3. Thickness of layer. Bitumen is an useful binder for road construction. Different grades of bitumen like 30/40, 60/70, and 80/100 are available on the basis of their penetration values and these grades can be used as IRC Specifications. Waste plastics (10% in place of bitumen) can be used for these different types of bitumen roads. The technology of road laying is very much the same as prescribed by the Indian Roads Congress (Section 500, IV revision) Specifications. A detailed description of the material required for laying of Semi Dense Bituminous Concrete (SDBC) 25 mm road (on existing road) is described below: -

a. Materials:

For 1000Mx3.75M (25mm) Road:	11.250 tons (60/70 grade) bitumen needed
Shredded Plastics Required : (passing 4.74mm sieve & retaining 2.36 mm)	10% by weight
Bitumen replaced (saved) by 10/ % Plastics	1.125 tons
Actual Bitumen Required	10.125 tons
Aggregate (11.2mm)	70.875 Cu.M
Aggregate (6.7mm)	43.125 Cu.M
Aggregate(6.7mm)	43.125 Cu.M
AggregateDust	23.625 Cu.M

b. Cost: The total cost including material as mentioned above, labour charge etc. (At Madurai) is approx. 5.00 lakh, however, the cost may be different from place to place and have to be calculated accordingly. The cost break-up is given below:

(i) Collection of littered plastics : Rs. 0.50 lakh

(ii) Cost of shredder and other equipment: Rs.0.50 lakh

(iii) Laying of road with material, labour etc. : Rs. 4.00 lakh

Total : Rs. 5.00 lakh

VI. COMPARISON

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

Conventional Bitumen Road at Madurai, Tamil Nadu Battered By Heavy Rain

Polymer-Aggregate-Bitumen Mix Road at Madurai,Tamil Nadu Undamaged By Heavy Rain

VII. CONCLUSION

Plastics will increase the melting point of the bitumen. 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. 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. 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.

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