

Utilization of Waste Plastic to Enhance Engineering Properties of Bitumen Roads

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ABSTRACT

The waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition, it will also be a solution to plastic disposal & various defects in pavement viz., pot holes, corrugation, ruts, etc. The waste plastic used are poly-ethylene, polystyrene, polypropylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and the resulting mix is used for pavement construction. This will not only strengthen the pavement and also increase its durability. The titanium-dioxide is used as a smoke absorbent material, which will absorb the smoke from the vehicles. This innovative technology will be a boon for Indian hot-humid climate. It's economical and eco-friendly. In this paper, we have discussed about the soil properties to be considered in design of pavement, pavement design, process of construction of flexible and plastic-smoke absorbent pavement.

Keywords: Waste, Plastic, Bitumen Roads, Pavement, Pollution, etc.

INTRODUCTION

The experimentation at several institutes, private organizations indicate that the waste plastic, when added to hot aggregate bituminous mix will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength to the road, higher resistance to the water and better performance of the road over a period of time. Waste plastic such as carry bags, disposable cups and laminated pouches like chips, pan masala, aluminum foil and packaging material used for biscuits, chocolates, milk and grocery items can be used for surfacing roads. The demand of bitumen is high and day by day demand is increasing as bitumen is produced from crude oil which is a non-renewable resource. Plastic waste has been constructed through simple process innovation in various states like Tamil Nadu, Karnataka, Himachal Pradesh and to a lesser degree in Goa, Maharashtra and Andhra Pradesh. The concept of "Use of Plastic Waste in Road Construction" was implemented in 2001 as a solution to the serious problem of disposal of Plastic Waste in India. The quantum of plastic waste in municipal solid waste (MSW) is increasing due to increase in population, urbanization, development activities and changes in life style which lead to widespread littering on the landscape. Thus disposal of waste plastic is a menace and becomes a serious problem globally due to their non-biodegradability and unaesthetic view. Since these are not disposed scientifically & possibility to create ground and water pollution.

This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix shows better binding property, stability, density and more resistant to water. The construction of every kilometre of road required nine tonnes of bitumen and one tonne of plastic waste. This means for every kilometre of road, one tonne bitumen is saved, which costs about Rs 30,000. Plastic roads consist of 6-8 per cent plastic, while 92-94 per cent is bitumen. Union minister Nitin Gadkari had announced the usage of plastic waste in road construction in 2016. Since then, plastic waste has been used in constructing one lakh kilometre of road in 11 states. In this financial year, the figure will double. The Municipal Corporation of Gurugram (MCG) used plastic waste in its roads for the first time in 2018. The MCG has now made the use of plastic waste mandatory in the construction of arterial roads.

A. Implementation of Plastic Roads in Pune and Chennai

Using bitumen technology on waste plastic, the Pune Municipal Corporation constructed a 150-metre stretch of Bhagwat lane at Navi Peth near Vaikunth Crematorium in 2016. The other trial patches in Pune include Dattawadi Kaka Halwai Lane, Katraj Dairy, Magarpatta City HCMTR Road, Kavde Mala Road, Koregaon Park Lane No 3 and Yeravada Sadal Baba Darga Road from Chandrama Chowk. According to the contractors, 90 per cent of bitumen is amalgamated with 10 per cent of plastic that includes everyday waste ranging from carry bags to miscellaneous items like biscuit and gutka packets. These products are shredded into small pieces and mixed with the liquid before laying it on the road. Contractors say that the cost of the entire process is not more than ₹ 325 per metre.

While the plastic roads may be a new concept in many parts of India, Chennai has been experimenting with it since 2011. Chennai has used nearly 1,600 tonnes of plastic waste to construct 1,035.23 kilometres length of roads in recent years, which include N.S.C Bose road, Halls road, Ethiraj Silai Street and Sardar Patel Street. In the last two years, the state rural development department had proposed 1,255 km long roads using plastic waste at a cost of Rs 153.5 crore. While 1,002 km roads have completed, the rest is expected to be completed soon. In the urban areas too, 1,065 km long plastic roads were planned and works are under various stages of completion.



Figure 1. Roads Constructed in Pune and Chennai using Waste Plastic

METHODOLOGY

A. Problem Statement

The plastic wastes could be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. Plastic is non biodegradable in nature, it remains in environment for several years and disposing plastic wastes at landfill are unsafe since toxic chemicals leach out into the soil, and under-ground water and pollute the water bodies. Due to littering habits, inadequate waste management system / infrastructure, plastic waste disposal continue to be a major problem for the civic authorities, especially in the urban areas. As stated above, plastic disposal is one of the major problems for developing countries like India, at a same time India needs a large network of roads for its smooth economic and social development. Scarcity of bitumen needs a deep thinking to ensure fast road construction.

B. Aim of the Study

- To make roads economical by using waste plastic which resolve plastic issue.
- To utilize the waste plastic efficiently in a constructive way such that it proves to be useful to the society.

C. Objectives of the Study

- Bitumen is nonrenewable resource by adding plastic we save good amt of bitumen which can be helpful for future generation.
- The primary objective of plastic roads is to reduce plastic waste, bags, bottles, etc. Not all plastic waste is recycled, as even the recyclable waste is just too much to reuse 100%.
- Bituminous roads are continuously being built and can incorporate extremely large quantities of plastic waste. Saving in cost is a bonus.
- Plastic-bitumen composite roads have better wear resistance than standard asphalt concrete roads. They do not absorb water; have better flexibility which results in less rutting and less need for repair. Road surface remain smooth, are lower maintenance, and absorb sound better.

EXPERIMENTAL STUDY

D. Selection of Waste Plastic

The waste plastic used are poly-ethylene, polystyrene, polypropylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and resulted mix is used for pavement construction. This will not only strengthen the pavement and also increases its durability. Thermoplastic polyethylene terephthalate (PET) polypropylene (PP) poly vinyl acetate (PVA) poly vinyl chloride (PVC) polystyrene (PS) low density polyethylene (LDPE) high density polyethylene

(hdpe). Thermosetting materials are not used in pavement construction. Bakelite Epoxy Melamine Polyester Urea-Formaldehyde Alkyd.

E. Selection of Aggregate

The aggregates are bound together either by bituminous materials or by cement. In a fewcases, the rock dust itself when mixed with water forms slurry which acts as a bindingmedium. The aggregates may be classified into natural and artificial aggregates. The natural aggregates again are classified as coarse aggregates consisting of crushed rock aggregates orgravels and fine aggregates or sand. The blast furnace slag obtained as by-product from blastfurnaces is the one extensively used as road construction material. Stone aggregate used for road work should be hard, tough, durable and hydrophobic for bituminous surface. Gravel should be well graded (10mm to 40mm) and should have a fineness modulus of not less than 5.75. Sand should be sharp, well graded.



Figure 2. Selection of Waste Plastic



Figure 3. Selection of Aggregate

F. Shredding of Waste Plastic

Waste plastics are cut in two or more pieces are fed into a shredder for further cutting. The plastic is cleaned before shredding and sometimes gets further cleaning after shredding according to manufacturer demand. The shredded machine use for thin film plastic is different from that use for rigid plastic.

Location of Shredding Machine: – Takli Road Narayan Babu Nagar Dasak.

G. Grade Selection of Bitumen

VG40 bitumen is used in areas in which high pressure comes from heavy traffic loads, such as intersections, near tolls booths, and truck parking lots. Due to the high viscosity of this bitumen, it is more appropriate for improving resistance to shoving and other problems associated with higher temperatures and heavy traffic loads. It's long time that industries use vg-40 instead of the penetration grade bitumen 40/50.



Figure 4. Shredding of Waste Plasti



Figure 5. Selection of Aggregate

RESULTS AND DISCUSSION

A. Test Result of Bitumen and Bitumen with Plastic

Table 1: Test Result of Bitumen and Bitumen with Plastic

Test	Bitumen 5%	Bitumen 5% with Plastic 6%
Moisture Absorption	4%	0.2%
Ductility	90 cm	74 cm
Penetration	63.50 cm	58.62 cm
Softening Point	52.6 °C	74.3 °C

B. Marshall Stability Test for Bitumen - 6%

Table 2: Test Result of Bitumen and Bitumen with Plastic

Bitumen Content	Plastic Content	Load (kN)	Displacement (mm)
Bitumen - 6%	Plastic – 0%	50.33	2.67
Bitumen - 6%	Plastic – 4%	52.08	2.48
Bitumen - 6%	Plastic – 5%	50.80	2.09
Bitumen - 6%	Plastic – 6%	51.72	1.80
Bitumen - 6%	Plastic – 7%	52.10	1.50

C. Marshall Stability Test for Bitumen - 7%

Table 3: Test Result of Bitumen and Bitumen with Plastic

Bitumen Content	Plastic Content	Load (kN)	Displacement (mm)
Bitumen - 7%	Plastic – 0%	53.04	1.67
Bitumen - 7%	Plastic – 4%	50.43	2.25
Bitumen - 7%	Plastic – 5%	53.15	1.75
Bitumen - 7%	Plastic – 6%	52.36	1.11
Bitumen - 7%	Plastic – 7%	51.02	1.07

D. Marshall Stability Test for Bitumen - 8%

Table 4: Test Result of Bitumen and Bitumen with Plastic

Bitumen Content	Plastic Content	Load (kN)	Displacement (mm)
Bitumen - 8%	Plastic – 0%	53.50	1.40
Bitumen - 8%	Plastic – 4%	52.58	1.09
Bitumen - 8%	Plastic – 5%	51.92	0.72
Bitumen - 8%	Plastic – 6%	50.79	0.55
Bitumen - 8%	Plastic – 7%	50.65	0.40

CONCLUSION

Plastics increase the melting point of the bitumen. The use of plastics in road construction is an innovative technology which not only strengthens the road but also increases the road life. The analysis in this paper reveals that Durability, strength and cost. 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. 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.

The use of the innovative technology not only strength of 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. The generation of waste plastics is increasing rapidly. Also the disposal of plastic is becoming complicated. So, using of the waste plastic in construction is a eco-friendly manner. The plastic coated bitumen increases the melting point. Polymer Modified Bitumen is used due to its better performance. The plastic coated bitumen helps in binding strength and increases the area of contact between the aggregate and bitumen. It also helps in eliminating of the voids. Due to the elimination of voids, road show the resistance

towards the oxidation of bitumen by entrapped air. This property makes the plastic coated bitumen road to withstand heavy traffic and show better durability.

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