International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 11 | November - 2022 Impact Factor: 7.185 ISSN: 2582-3930

USE OF WASTE PLASTIC IN CONSTRUCTION OF BITUMINOUS ROAD: A Review

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Abstract -

Waste plastics and their disposal are a major threat to the environment, resulting in pollution and global warming. The use of plastic waste in bituminous mixtures increases its properties and strength. In addition, it will also be a solution to the disposal of plastics. The waste plastics used are polyethylene. The waste plastic is crushed and spread on aggregate and mixed with hot bitumen and the resulting mixture is used for road construction. This will not only strengthen the pavement, but also increase its durability. Titanium dioxide is used as a smoke absorbing material that absorbs smoke from vehicles. This innovative technology will benefit India's hot and humid climate. It is economic and ecological. In this article, we have discussed the soil properties that need to be considered in roadway design, roadway design, flexible construction process. Therefore, this study is expected to help minimize the pollution caused by plastic and thus develop an environment-friendly technology. The aim of this paper is to review the relevant literature that published related to use of waste plastic in construction of bituminous road. By studying 10 research papers, focused on various strategies, tools, techniques and methodologies.

***Key Words*:** Plastic waste, Flexible pavement, Strength.

1.INTRODUCTION

- India produces 1,88,000 tons of waste every day. Plastic waste in various forms constitutes almost 9 to 12% in municipal solid waste, which is toxic in nature. The non-biodegradability of plastics in the environment has created a number of challenges for both urban and rural areas of India. Common problems are clogging of drains, stagnation of water and the release of toxic gases during open burning. Research experiments have been conducted in both the public and private sectors to address the growing environmental challenge. Disposal of various wastes from various industries is a big problem nowadays.
- These materials represent environmental pollution in the nearby location because many of them are not biodegradable. Soil, aggregate, sand, bitumen, cement, etc. are traditionally used for road construction. Natural materials are exhaustible in nature and their quantity is gradually decreasing. The cost of extracting quality natural material is also increasing. Because of this, scientists are looking for alternative materials for the construction of highways, and one of these categories is the product of industrial waste.
- If these materials can be used appropriately in highway construction, pollution and disposal problems can be partially reduced. In the absence of other outlets, these solid wastes occupied several acres of land around plants across the country. Considering the need for mass utilization of these solid wastes in India, it was considered expedient to test these materials and develop specifications for increasing the utilization of these industrial wastes in road construction where higher economic returns are possible.
- The possible use of these materials should be developed for the construction of small-volume roads in different parts of our country. The necessary specifications should be formulated and an attempt should be made to maximize the utilization of solid wastes in the various layers of the pavement. Post-construction roadway performance studies are to be conducted for these waste materials for small-volume road construction, with the dual benefit of: (a) helping to clear valuable land of huge waste dumps; b) will also contribute to the preservation of natural reserves of aggregates, and thus to the protection of the environment. Plastics are user-friendly, but not environmentally friendly, as they are generally non-biodegradable, disposed of by landfilling or incineration of hazardous materials.
- Plastic is a versatile material and the common man's friend becomes a problem for the environment after its use. The better binding properties of plastics in the molten state helped to find a way to safely dispose of waste plastics. Pure bitumen road surfaces may bleed in hot climates, crack in cold climates, have less bearing capacity, and may cause serious damage due to higher axle loads in current conditions due to rapid infrastructure development.
- The life of asphalt layers is said to have decreased by 7-8 from an average life of 5-6 years in the past to about 3-4 years at present compared to the average life of roads (5-6 years) abroad. India needs to take the transport system to a higher level both in terms of length and quality.
- This study presents the use of waste in hot bituminous mixtures to improve pavement performance, protect the environment and provide low-cost roads. Polymer and plastic modified bitumen, often referred to as modified bitumen, is obtained by incorporating selected thermoplastics and shredded plastic from discarded waste, natural plastic or any other suitable elastomers in the bitumen.

2. OBJECTIVE

- Determination of bitumen strength after mixing plastic waste.
- Compare regular and modified asphalt.
- Compare the estimate of total costs for both asphalts.
- Understand the administrative processes associated with the use of plastic waste in road construction
- To assess the progress of incorporation of relevant guidelines and rules of Indian Roads Congress regarding use of plastics in various types of road constructions.
- Identify any problematic concerns.
- Emphasize the costs associated with implementation.
- Evaluate methods of coordination between municipal authorities dealing with disposal of plastic waste and road construction unions using waste in road construction.
- To assess to what extent the innovation could solve the issue of the best possible disposal of solid waste (plastics) faced by municipal authorities.
- Recognize the need for the media's role in creating public awareness in replicating this innovation.

3. SCOPE OF WORK

- Assessing the durability of plastic in comparison to other materials by comparing use and on a limited performance scale.
- Assessment would be selective to highlight best practices and operational parameters.
- Assessment of plastics such as polyethylene, polypropylene, polystyrene, among others, as specified in IRC SP-98.

4. METHODOLOGY

4.1 Primary Research:

- Primary research involved field visits and interaction with operational participants and stakeholders involved in plastic road construction. The objective of the primary research was to collect qualitative and quantitative data along with supporting documents. This was done to improve service delivery and improve the prospects for replication elsewhere in the country.
- Primary research was critical in developing a detailed understanding of plastic road implementation. In case it was not possible to meet the workers in the field, telephone interviews were conducted. Field visits helped to develop observations of beneficiary use and semi-structured interviews with key stakeholders.

4.2 Secondary Desktop Research:

- Secondary research included desktop analysis of technical, administrative, regulatory and organizational aspects of the project. The scope of these references varied from global, regional and local. The range of secondary research sources included:
- Journals, patents, government reports, working papers and case studies to develop a holistic understanding of the context and need for innovation.

5. LITERATURE REVIEW

- **Dr.R. Vasudevan (2007) -**
- Polymeric bitumen mixture has been reported to be a better binder compared to plain bitumen. The mixture has an increased softening point and a reduced penetration value with suitable ductility.
- **Zahra Niloofar Kalantar (2012) –**
- Much research has been done on PMA mixture in the last two decades. Although the addition of new polymers to asphalt to improve asphalt properties over a wide temperature range in pavement applications has been considered for some time, recycled polymer added to asphalt also showed almost the same result in improving pavement properties as compared to virgin polymers. This article is an overview of the use of polymers in asphalt pavements. In this study, a critical review of the history and benefits of using waste and virgin polymers in asphalt is presented.
- **R. Manju et al** /International Journal of Chemtech Research, 2017,10(8): 804-811. 806 followed by a review of general studies on the use of polymers in asphalt to improve pavement performance.
- **Amit Gawande (2012)-**
- The amount of plastic waste in municipal solid waste (MSW) is increasing as a result of population growth, urbanization, development activities and lifestyle changes that lead to widespread pollution of the landscape. Thus, the disposal of waste plastics is a threat and is becoming a serious problem worldwide due to its biodegradability and unsightly appearance. As these are not disposed of scientifically and can cause soil and water pollution. This waste plastic partially replaced the conventional material to improve the required mechanical properties for a specific road mix. In the conventional road-making process, bitumen is used as a binder. Such asphalt can be modified with waste plastic pieces to produce an asphalt mixture that can be used as the top layer of flexible

pavement11. This waste plastic-modified asphalt mixture exhibits better binding properties, stability, density and is more resistant to water.

- **Rishi Singh Chhabra (2014) -**
- A large number of original materials and technologies were invented in the highway infrastructure, which determined their suitability for the design, construction and maintenance of these roads. Plastics and rubbers are one of them. Also considering the ecological approach, environmental pollution due to excessive use of polythene in daily business is enormous. The use of plastic materials like bags, cups, etc. is constantly increasing day by day10. Since polyethylene is non-biodegradable, there is currently a need to use waste polyethylene for some beneficial purposes. The use of these materials as a road construction proves to be ecological, economical, and the use of plastic gives strength in the underlying road layer.
- **Prof.C.E.G. Justo-**
- states that the addition of 8.0% by weight of processed plastic to prepare modified asphalt results in a saving of 0.4% asphalt by weight of the mix or about 9.6 kg of asphalt per cubic meter (m 3) of BC mix. Modified bitumen improves the stability or strength, durability and other desirable properties of bituminous concrete mixture forms.
- **V.S. Punith, (2001)-**
- Some encouraging results have been reported in This study shows that there is an opportunity to improve the properties of bituminous road pavement mixtures. Waste plastics (polyethylene bags, etc.) soften when heated at around 130°C. Thermogravimetric analysis showed no gas evolution in the temperature range of 130-180°C. Plasticized plastics have a binding property. Therefore, it can be used as a binder for road construction.

6. TECHNOLOGY

The quantum of plastic waste is estimated to be roughly 10 thousand tons per day (TPD). The two major categories of plastics are:

(i) Thermoplastics and (ii) Thermosetting plastics. The Thermoplastics include Polyethylene Terephthalate (PET), Low Density Poly Ethylene (LDPE), Poly Vinyl Chloride (PVC), High Density Poly Ethylene (HDPE), Polypropylene (PP), Polystyrene (PS) etc. and are recyclable. Thermosetting plastics constitute alkyd, epoxy, ester, melamine formaldehyde, phenolic formaldehyde, silicon, urea formaldehyde, polyurethane, metallized and multilayer plastics etc. A mismanagement of plastics waste is a threat to the environment in the following ways (1):

1. Drains are choked and public places become filthy due to the littered plastics.
2. The emission of polluting gases due to burning of garbage containing plastics may cause air pollution.
3. Garbage mixed with plastics hinders the waste processing facilities may be a cause of issues in landfill operations.
4. Some unhygienic hazards to the environment are being caused by recycling industries operating in non-conforming areas.

One of the ways of managing waste plastic is by using it in construction material for pavements and roads which serves the dual purposes of imparting stability and durability to the roads and resolving the issue of environmental hazard due to ever increasing waste plastics. To understand the role of plastics in construction material, one must be familiar with the material specific properties and the processes used in laying roads. Having said this, further discussion details the use of each component and the processes involved in creating construction material.

7. CHARACTERIZATION OF PLASTIC WASTE BITUMEN MIXES

The employment of plastic waste as modifier is successful only if it coats the aggregate well and the aggregate becomes non-wetting with enhanced mechanical properties. In order to check for the inclusion of plastic in the aggregate bitumen mix, various characterization techniques have been used and listed here:

7.1 Stripping test (IS: 6241-1971):

PCA bitumen mix made by dry process is immersed in water for long hours. Absence of stripping of the plastic material from aggregate mix ensures good resistance towards water due to excellent coating of plastic waste over aggregate making it Use of Plastics in Road Construction Centre for Innovations in Public Systems non-wetting. Further, this would also ensure better binding of bitumen with the aggregate through the plastic layers.

7.2 Marshall Stability Test:

Effective binding of bitumen with the aggregate mix through plastic layers would have a positive effect on the stability of the bitumen-aggregate mix. Marshal stability values determined for PMB mixes are generally much higher than pure bitumen mix.

7.3 Water absorption test:

Aggregate mix is dried, weighed and then immersed in water for a day and dried again. The weight was determined to check for the amount of water absorbed by aggregate mix. Then a known amount of aggregate mix is heated and coated with plastic and the plastic-coated aggregate mix is immersed in water, removed, dried and weighed. The process is repeated three times for each sample. The same experiment was carried out for aggregates coated with different amounts of plastics.

The water absorption decreases with the coating of plastic over aggregate.

7.4 Extraction of bitumen:

Bitumen is extracted from aggregate coated with bitumen only, plastic coated aggregate mix (using Dry process) and aggregate mixed with plastic waste blended bitumen (Wet process) using benzene as a solvent. Removal of bitumen is difficult in case of plastic waste coated aggregate mix (Dry process) than plastic waste blended bitumen mix. This confirms that the dry process is better than the wet process.

8. MATERIAL

8.1 BITUMIN

"Bitumen is a hydrocarbon material of natural or pyrogenous origin, which is in a gaseous, liquid, semi-solid, or solid state, and which is completely soluble in carbon di sulphide (CS2)." Of course, bitumen is found to be soluble to a large extent in carbon tetrachloride (CCl4) also. Bitumen is a complex organic compound and occurs either as such in nature or can be obtained during the distillation of petroleum; it is generally non-volatile and resistant to most acids, alkalis and salts.

Bitumen occurring in nature as rock intrusions invariably contains inert inorganic materials or minerals; in such a case it is called asphalt. It is also found in lakes (as in Trinidad), in which case it is called lake asphalt. However, in American terminology, bitumen itself is termed asphalt, irrespective of whether it contains inorganic/mineral matter or not. In India, the British terminology is used for the term's bitumen and asphalt.

- **Important Properties of Bitumen:**

1. Predominantly hydrocarbons, with small quantities of sulphur, nitrogen and metals.
2. Mostly (up to 99.9%) soluble in carbon disulphide (CS2), and insoluble in water.
3. Softens on heating and gets hardened on cooling.
4. Highly impermeable to water.
5. Chemically inert and unaffected by most acids, alkalis and salts.
6. No specific boiling point, melting point or freezing point; a form of 'softening point' is used in their characterization.
7. Although generally hydrophobic (water repellent), they may be made hydrophilic (water liking) by the addition of a small quantity of surface-active agent.
8. Mostly bitumen is colloidal in nature.
9. Desirable Properties of Bitumen as a Road Material:
10. Workability – Bitumen should be fluid enough at the time of mixing so that the aggregates are fully coated by the binder. Fluidity is achieved either by heating or by cutting back with a thin flux or by emulsifying the bitumen.
11. Durability – There should be little change in viscosity within the usual range of temperatures in the locality.
12. Volatile constituents in bitumen should not be lost excessively at higher temperatures to ensure durability.
13. It should have enough ductility to avoid brittleness and cracking.
14. Strength and adhesion – The bitumen should have good affinity to the aggregates and should not be stripped off in the continued presence of water.
15. Cost-effectiveness.

9. ADVANTAGES AND DISADVANTAGES

ADVANTAGES

- Reduce the need for bitumen by about 10%.
- Develop technology that is environmentally friendly.
- Improving the fatigue life of roadways.
- Increase strength and better road performance.
- Use a higher percentage of plastic waste.
- Gases released during operation are absorbed by the smoke absorbent

DISADVANTAGES

- Toxic substances present in the mixed plastic waste would start to leach out.
- The presence of chlorine will definitely release HCL gas.

10. CONCLUSION

- The addition of waste plastic modifies the properties of the bitumen.
- Modified bitumen shows good results compared to standard results.
- Problems such as bleeding are reduced in the high temperature area.
- Plastic has the ability to absorb sound, which also

helps reduce noise pollution from heavy traffic.

- Waste plastics can thus be used and ultimately improve the quality and performance of the road.
- The result is a reduction in ruts and no potholes.
- Plastic paving can withstand heavy traffic and is more durable than flexible paving.

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ACKNOWLEDGEMENT

We sincerely express my deep sense of gratitude towards our Guide Prof. Priyanka Patil, for constantly guiding and encouraging us throughout the tenure of the project thesis, because of which project thesis entitled **"USE OF WASTE PLASTIC IN CONSTRUCTION OF BITUMINOUS ROAD: A Review"** could come in its current form. We would like to express hearty sincere thanks to the guides for their constant support and for giving their valuable time form their busy schedules.

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