Pavement Design by Using Recycled Plastic

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***Abstract*—The heavy use of plastic wrappers for items like chips, carry bag, cold drink bottles, milk packets, present negative impact on environment, industrial sector favour plastic for its affordable price, light in weight, and its robust quality. Improper disposal of non-biodegradable plastic remain challenge for environment.By subsitituting part of these materials with waste plastic, road construction becomes more sustainable and environment friendly. One innovative method to handle the plastic waste problem by utilize in road construction, especially in bituminous mix.Waste plastic primarily used for packing are composed of Polyetylene, Polystyrene, and Polypropylene their softening point range between 110 °C to 140 °C and they do not emit harmful gases during softening.However, the softened plastic have tendency to create a film like structure above the aggregate.The formed Plastic Coated Aggregate is a superior raw material for the construction of flexible pavement.These plastic coated aggregate was later mixed with hot bitumen of various types and mixes were used for road construction.Plastic coated aggregate and bitumen mix enhance binding property. The application of plastic waste in road construction provide a valuable opportunity to not only upgrade pavement performance, but also lessen the problem of plastic waste disposal.Conventional road construction materials such as asphalt, consume large amount of natural resources like aggregate and bitumen, resulting in environmental damage and depletion of resources.One of the main advantages of using plastic waste in road construction is its ability to strengthen the characteristics of bituminous mixes.Waste plastic when properly treated and blended with bitumen can increase the flexibility, strength and durabilty of pavement. By shifting plastic waste away from landfills and ocean and utilising it into infrastructure development project, society can effectively lower its environmental impact and support a circular economy model.**

***Index Terms*—Polyetylene, Polystyrene, Polypropylene, Plastic Coated Aggregate, Bitumen, Waste Plastic, Aggeragate, etc.**

I. INTRODUCTION

Plastic, with its versatile properties, has transformed various industries, offering durability, flexibility, and cost-effectiveness. From packaging materials to consumer goods, plastic has become an essential part of modern life. In addition, the extensive use and disposal of plastic products have led to a significant environmental challenge plastic waste pollution. The non-biodegradable nature of plastic, coupled with improper disposal practices, has resulted in the collection of plastic waste in landfills, oceans, and natural habitats worldwide.The ubiquity of plastic waste causes serious risk to ecosystems, wildlife, and human health.

Plastic debris in the environment not only detracts from the aesthetic appeal of landscapes but also causes hazards to marine life through ingestion and entanglement. Furthermore, plastic pollution has been connected to various environmental problem including soil and water contamination, greenhouse gas emissions, and microplastic pollution.

In urban areas, the collection of plastic waste increases environmental degradation and lead challenges to waste management systems. Despite attempts to encourage recycling and reduce single-use plastics, the total amount of plastic waste produced yearly continues to strain existing infrastructure and resources. The need for innovative solutions to address the plastic waste crisis has never been more pressing. Identifying the importance of the situation, researchers and policymakers have increasingly turned their

attention to finding sustainable alternatives for plastic waste management.

One promising solution is the utilization of plastic waste in road construction, particularly in bituminous mixes used for pavement surfaces. Bituminous concrete, commonly known as asphalt, is a composite material comprising asphalt or bitumen and mineral aggregate. It forms the foundation of most road surfaces, providing durability stability, and skid resistance.

By adding waste plastic into bituminous mixes, researchers objective to not only tackle the environmental challenges caused by plastic waste but also enhace pavement performance and durability. Plastic-modified pavements have shown effective results in resisting temperature fluctuations, reducing moisture infiltration, and enhancing overall pavement quality. Furthermore, the utilization of waste plastic in road construction presents an potential to minimize the consumption of virgin materials and promote a circular economy model. One of the key advantages of using waste plastic in road construction is its capacity to enhance the properties of bituminous mixes. Plastic, when properly processed and mixed with bitumen, can improve the flexibility, strength, and durability of pavements.

Moreover, plastic-modified pavements have shown greater resistance to temperature-induced cracking and moisture infiltration, making them especially suitable for regions with extreme weather conditions. The technique of using waste plastic in road construction is not new. Other countries, including India, have already incorporate waste plastic into pavement construction projects.

The Plastic Road initiative launched in 2015 by the Indian Ministry of Road Transport and Highways, goal is to utilize waste plastic in road construction to tackle both infrastructure needs and plastic waste management challenges. The benefits of plastic-modified pavements extend beyond environmental conservation. By creating demand for recycled plastic materials, road construction projects can stimulate the growth of local recycling industries, generate employment opportunities, and empower marginalized communities. Moreover, plastic-modified pavements have the potential to reduce maintenance costs and extend the service life of roads, resulting in long-term economic savings for governments and taxpayers.

II. OBJECTIVE

The application of plastics in road also opens a new alternative option for recycling waste plastic. Australia, United Kingdom, India United States and other countries have used technique, which can include plastic waste into an asphalt mix. In India, plastic road developed by Rajgopalan Vasudevan in 2001 consist of an asphalt mix with plastic waste incorporated into the asphalt mixture.

Utilization of waste plastic is innovative technique to reuse plastic waste to construct better, more durable and cost-effective roads. This technique will help in making roads much faster and also will save the environment from dangerous plastic waste. The roads also show greater resistance to damages caused by heavy rains. This technique is easy and does not need any new machinery. Plastic has versatile properties, which enhance aggregate impact value and improves quality of flexible payment, reduce wear and tear of roads

Rapid increase in plastic consumption become a essential to identify innovative technique that can convert waste plastic into useful construction resources. Utilization of waste plastic in pavement design enhance the bonding characteristics between aggregate and bitumen and also improves its properties, reducing pothole formation, minimize stripping action.

III. MATERIALS

1. Aggregate

Aggregate is an inactive material implemented in road construction. Bitumen holds these naturally occurring stones together, as they have very little reactivity. In addition, larger rocks are artificially processed by being broken into small pieces. Aggregate such as crushed stone, gravel, or basalt are primarily used to provide strength and load-bearing capacity.When recycled plastic is added, it is melted and coats the surface of these hot aggregates, enhancing adhesion with bitumen and reducing moisture absorption. Stone aggregate used for work should be hard, tough, durable and hydrophobic, 10 mm coarse aggregates are used.

2. Bitumen

Bitumen can be generated artificially through chemical processes or obtained as a by- product of

crude oil distillation. They have an ectremely dense structure and are made up of complex hydrocarbons. Bitumen acts as a binding agent, supporting the aggregates together. Bitumen is simply utilized for road construction because of its ductility, low melting point, and binding ability.

3. Waste Plastic

In this project, the bituminous mixture used to produce the flexible pavement includes waste plastic. This innovative solution minimises the volume of plastic waste that ends up in landfills, recycles it, and enhances the qualities of bituminous mix. The bitumen that has been processed with plastic shows better flexibility, more resistance to rutting and cracking, and may even lengthen the pavement's life.

IV. METHOD AND METHODOLOGY

- Dry method

In this method, shredded plastic is incorporated immediately to hot aggregates, where it melts and creates a thin plastic film coating over the aggregate surface. This coating improves the bonding between bitumen and aggregates, increases water resistance, and enhances stability. The dry process is the most widely used technique in India for incorporating waste plastic into flexible pavements.

- Methodology

1. Segregation

Plastic waste are collected from differents sources undergoes to detailed segregation to separate it from other waste materials. This process maintains the quality of the plastic waste and simplifies its following treatment and incorporation into bituminous mixes.

2. Cleaning Process

The segregated plastic waste undergoes strict cleaning and drying procedures to eliminate all contaminants, impurities or moisture. This step is essential to ensure the quality and suitability of plastic waste for road construction applications. Clean and dry plastic waste improves the ashesion and dispersion of plastic particles within the bituminous mix, thus improving pavement performance.

3. Shredding Process

The cleaned plastic waste is shredded or cut into tiny, uniform pieces to facilitate its uniform distribution and integration into the bituminous mix.

Proper shredding verifies the homogeneous dispersion of plastic particles across the mix, thus enhacing the overall stability, durability, and performance of the pavement.

4. Collection Process

Plastic waste particles kept on a 2.36 mm IS sieve are carefully collected for further treatment and incorporation into bituminous mixes. Selecting appropriate particle sizes confirms optimal consistency and interlocking between plastic particles and other mix components, maximizing pavement performance.

V. EXPERIMENTAL PROGRAM

We perform experiment by using 8% and 15% waste plastic content by weight of bitumen.

Table no. I Material quantity

For 8% waste plastic	For 15% waste plastic
Aggregate – 5000 gm Bitumen – 230 gm Waste plastic- 20 gm	Aggregate – 5000 gm Bitumen – 213 gm Waste plastic- 38 gm

- Procedure

1. Collection of waste plastic
2. Cleaning of waste plastic
3. Shredding process
4. Heating of aggregate
5. Sprayed shredded plastic on hot aggregate
6. Add bitumen

- Test and Results

Table no. II Results

S.NO.	Tests	8% waste plastic	15% waste plastic
1.	Aggregate impact value test	15%	11%
2.	Water absorption test	1.5%	0.5%
3.	Penetration test	55 dmm	42 dmm
4.	Softening test	53 °C	61 °
5.	Marshall stability test	1500 Kg	1660 Kg

Now, we also perform experiment on 12% waste plastic content for more desired results.

Table no. III Result on 12% waste plastic.

S.NO.	Tests	12% waste plastic
1.	Aggregate impact value test	13%
2.	Water absorption test	1%
3.	Penetration test	50 dmm
4.	Softening test	57 °C
5.	Marshall stability test	1745 Kg

VI. PERFORMACE OF ROAD

It is observed that plastic roads laid are indicating results which are the characteristics of a good road. The results obtained for plastic coated aggregate bituminous roads show that these roads are performing very well in spite of their age. These roads have not developed even small cracking or pothole. The roads were exposed to various environmental conditions like temperature, rainfall, etc. yet the roads are performing well. Under similar conditions, most of the bituminous roads are not performing well. Therefore it can be determined that the plastic roads are performing much better than the plain bitumen road.

VII. PROPERTIES

- Advantages

1.Plastics comes with multiples chemical and physical properties, road can be engineered to fulfill specific requirement.

2. Plastic roads can be developed from waste plastic the mostly of which is generally put into landfill, incinerated, or polluted into the environment. Land-filling and incinerating plastic are both difficult methods of handling plastic waste. Plastics in landfills can seep pollutants into the nearby soil.

3. Using less asphalt saves on cost and resources. Asphalt concrete need petroleum which is becoming more limited.

4. Plastic-bitumen composite roads have improved wear resistance than standard asphalt concrete roads. They do not absorb water; have better flexibility which effects in less rutting and less need for repair. Road surfaces stay smooth, are lower maintenance, and absorb sound better.

- Disadvanages

1.Plastics in the road can degrade into microplastics and can find their way into the soil and bodies of water. These microplastics can also capture other pollutants.

2. Whenever maintenance is conducte on these modular roads the movement of power, water, and internet that has been placed within will be disrupted

VIII. CONCLUSION

Integrating 8%, 12%, and 15% waste plastic into bitumen serves as an effective binder modifier, significantly enhancing the strength, stability and longevity of pavements compared to traditonal mixes. 12% waste plastic content provides the best balance of stability and strength, whereas 8% is commonly suitable for safety and reliability and 15% may lead to reduced, excessive rigidity, reduced workability during laying and risk of poor mixing.

Table no. IV Discussion

S.No.	Waste plastic content	Stab-lity	Flexibilt-y	Overall Perform-ance
1.	8%	Good	Good	Very good
2.	12%	High	Balanced	Best
3.	15%	Low	Low	Suitable

REFERENCES

[1] Vasudevan R, Rajasekaran S, Saravanavel S. Reuse of waste plastics for road laying Indian Highways (Indian Roads Congress), vol. 34, no. 7.

[2] Yash Menaria and Rupal Sankhla " USE OS WASTE PLASTIC IN FLEXIBLE PAVEMENT-GREEN ROADS" , Open Journal of Civil Engineering,2015, 5, 299-311.

[3] Performance evaluation of polymer coated bitumen-built roads, Probes/121/ 2008-2009. Central Pollution Control Board, New Delhi

[4] IRC SP 98 -2019 ""Guidelines for the use of waste plastic in hot bituminous mixes (dry process) in wearing courses.

[5] Rajasekaran, S., Vasudevan, R. and Paulraj, S. (2013) Reuse of Waste Plastics Coated

Aggregates-Bitumen Mix Composite for Road Application- Green Method. American Journal of Engineering and Research, 2, 1-13.