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Eco-Friendly Waste Plastic Road

Rabani Saphi[1], Akash Chand[2], Sital Phuyal[3], Yamu Chhetri[4], Ravi Shankar Chaudhary[5], Dr. Tripti Khanduri[6], Mohit Bisht[7]
[1, 2, 3, 4, 5]Student, Department of Civil Engineering, Tula's Institute, Uttarakhand India
[6, 7]Assistant Professor, Department Of Civil Engineering , Tula's Institute, Uttarakhand India

Abstract: The rapid increase in plastic waste has become a major environmental challenge across the world. Simultaneously, the construction of flexible pavements requires significant quantities of natural aggregates and bitumen, resulting in resource depletion and environmental degradation. This research investigates the use of waste plastic in asphalt pavement construction for developing eco-friendly plastic roads. The study compares conventional asphalt mixes with plastic-modified asphalt mixtures in terms of Marshall Stability, durability, water resistance, and environmental benefits. Laboratory results indicate that plastic-modified roads exhibit improved strength, higher resistance to rutting, reduced moisture damage, and longer service life compared to conventional pavements. The optimum performance was observed at approximately 8% plastic content in the bituminous mix. The study concludes that waste plastic can be effectively utilized in road construction to reduce environmental pollution and enhance pavement performance.

I. INTRODUCTION

Road transportation plays an essential role in economic growth and infrastructure development. However, conventional road construction consumes large amounts of natural resources and bitumen. At the same time, plastic waste disposal has emerged as a critical environmental issues due to increasing urbanization and industrialization.

Plastic waste is non-biodegradable and accumulates in landfills, rivers, and oceans, causing severe ecological damage. Researchers have proposed incorporating waste plastic into bituminous pavements as a sustainable solution. Plastic modified asphalt improves pavement strength, flexibility, and durability while simultaneously reducing environmental pollution. The use of recycled plastic in asphalt mixtures is generally carried out through the dry process, where shredded plastic coats heated aggregates before the addition of bitumen. Studies have shown that this process enhances Marshall Stability, rutting resistance, and moisture resistance of pavements.

II. LITERATURE REVIEW

Several researchers have investigated the application of waste plastic in road construction.

R. Vasudevan reported that waste plastic roads possess better durability and water resistance compared to conventional pavements. Plastic coating improves aggregate bonding and reduces pothole formation.

Shah et al. investigated the influence of PET, LDPE, and HDPE plastics in hot mix asphalt. Their findings indicated that increasing plastic content improved Marshall Stability and pavement performance, with 9% LDPE producing the best results. A review conducted by Shah et al. summarized that waste plastics significantly improve fatigue resistance, rutting resistance, and Marshall properties of asphalt pavements. Heydari et al. critically reviewed the dry and wet processes of asphalt modification using plastic waste and concluded that plastic waste generally increases Marshall Stability while decreasing flow values. Wu and Montalvo highlighted that recycled plastics can serve as sustainable alternatives in asphalt pavement construction while supporting circular economy principles and reducing environmental pollution.

III. METHOLODOGY

A. Materials Used

Material	Purpose
Bitumen	Binding Material
Aggregates	Structural Strength
Waste Plastic (LDPE, HDPE, PET)	Pavement Modification
Filler Material	Stability Improvement

Table. III. A. 1. Materials and its Purposes

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B. Experimental Procedure

- Collection of waste plastic materials.
- Cleaning and segregation of plastic waste.
- Shredding plastic into small pieces.
- Heating aggregates to 160–170°C.
- Mixing shredded plastic with hot aggregates.
- Addition of bitumen to prepare asphalt mix.
- Preparation of Marshall specimens.
- Conducting Marshall stability and flow tests.

C. Process Flow Diagram

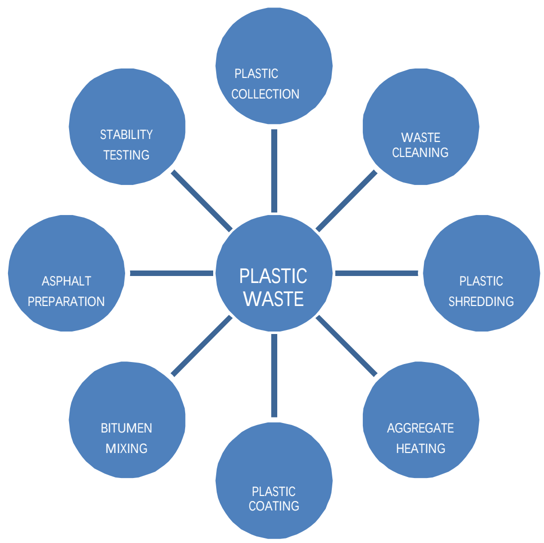

Fig. III.C. 1. Flow diagram of Plastic Waste

D. Pavement Structure

Fig. III. D. 1. Flexible Pavement

IV. EXPERIMENTAL RESULTS

A. Marshall Stability Test Result

Mix Type	Stability (kN)	Flow Value (mm)
Conventional	9.4	3.9
4% Plastic Mix	10.8	3.7
6% Plastic Mix	11.8	3.5
8% Plastic Mix	13.6	3.2
100% Plastic Mix	12.9	3.1

Table. IV. A. 1. Marshall Stability Test

The results indicate that Marshall Stability increased significantly with the addition of waste plastic.
Maximum stability was achieved at 8% plastic content, after which a slight decrease was observed due to excessive stiffness in the mix.

B. Comparison Between Conventional and Plastic Road

Parameter	Conventional Road	Plastic Road
Marshall Stability	Lower	Plastic
Water Resistance	Moderate	Excellent
Cracking Resistance	Moderate	High
Pavement Life	5-7 Years	8-12 Years
Maintenance Cost	High	Low
Environmental Impact	High Pollution	Eco-Friendly

Table. IV. B. 1. Comparison between Conventional And Plastic Road

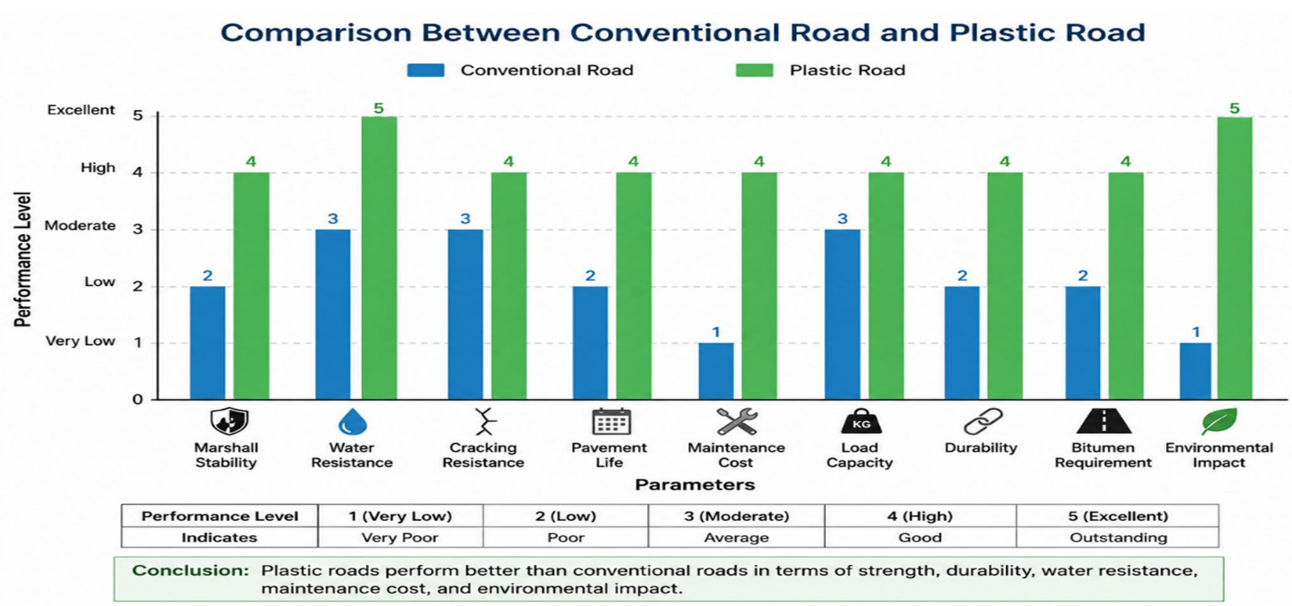

Fig. Iv. B. 1. Comparison Between Conventional Road And Plastic Road

Conventional roads cause higher environmental pollution because they use large amounts of bitumen and require frequent maintenance. They are also more likely to develop cracks and potholes. In contrast, plastic roads are more eco-friendly because they reuse waste plastic materials in road construction. Plastic roads are stronger, more durable, and have better water resistance, which reduces maintenance costs and helps in managing plastic waste effectively. Therefore, plastic roads are considered a sustainable and environmentally friendly alternative to conventional roads.

V. DISCUSSION

A major accomplishment achieved in incorporating waste plastic for asphalt pavement materials was the enhancement of the performance properties of the resulting material. There was a better bond between the plastic coated aggregates and bitumen, leading to higher Marshall Stability and lower flow value for plastic coated aggregates. Roads modified with plastic had greater resistance to moisture damage and rutting than did conventional roads. The main reason for this improvement is the thermoplastic nature of waste plastics, which make the asphalt mixtures stiffer and less water absorbing. Additionally, the study showed the positive effects on the environment, as the project reduced the amount of waste sent to landfill and used less virgin construction materials. Use of waste plastic in road construction is in line with sustainable development goals and is conducive to the development of sustainable roads.

VI. CONCLUSION

This research demonstrates that waste plastic can be effectively utilized in flexible pavement construction to produce eco-friendly plastic roads. The experimental analysis showed that plastic-modified asphalt mixtures possess higher Marshall Stability, improved durability, and better resistance to water damage compared to conventional asphalt pavements.

The optimum plastic content was found to be approximately 8%, which provided the highest pavement stability. The use of waste plastic in roads not only improves pavement performance but also helps address environmental concerns associated with plastic waste disposal.

Therefore, eco-friendly plastic roads provide a sustainable, economical, and durable solution for future transportation infrastructure.

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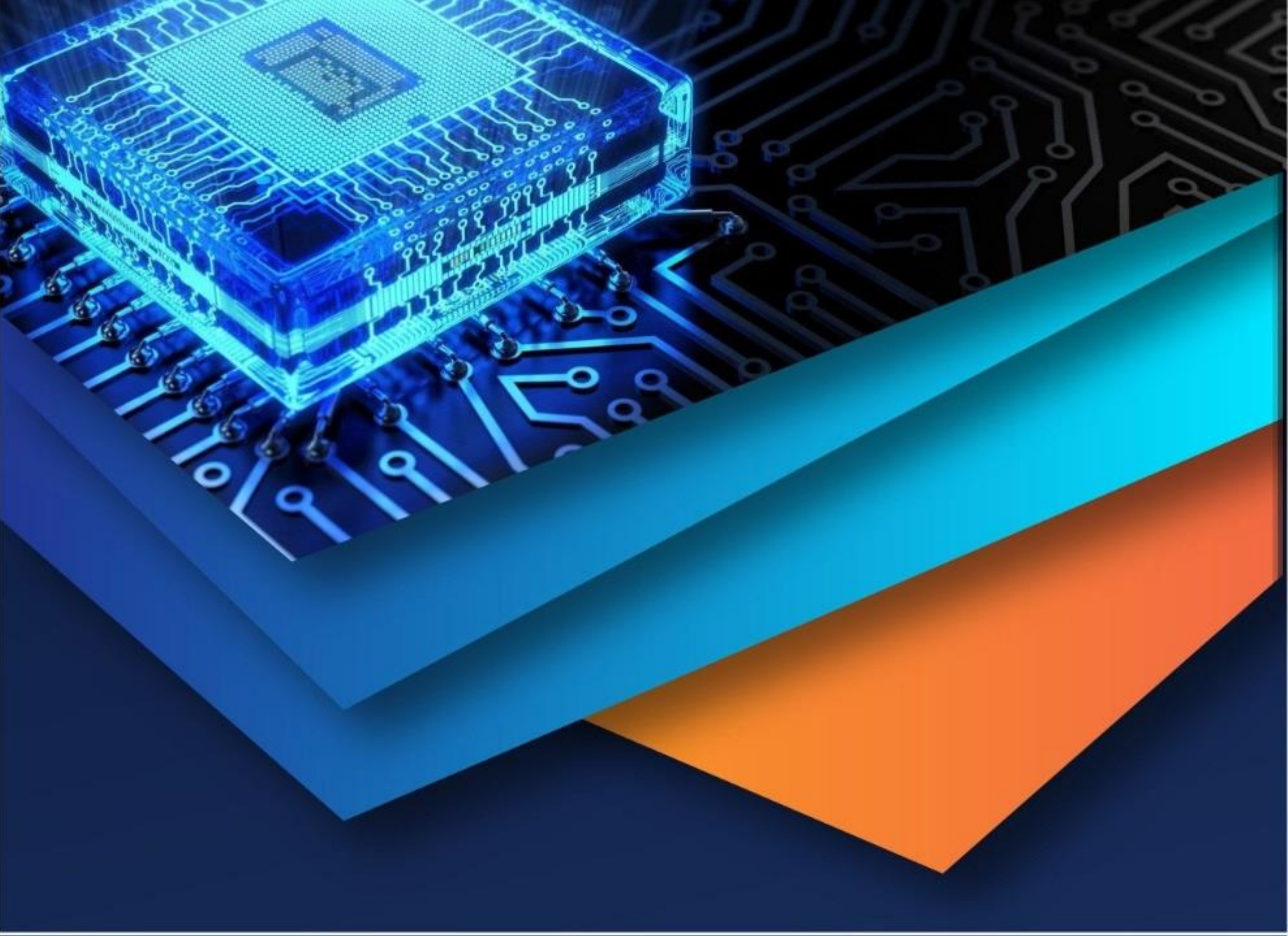

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