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AN EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF PLASTIC IN BITUMEN FOR FLEXIBLE PAVEMENT CONSTRUCTION

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ABSTRACT

Plastic waste has become one of the major environmental concerns across the world. At the same time, the demand for durable and long-lasting roads is increasing rapidly. This study focuses on the utilization of waste plastic as a partial replacement for bitumen in flexible pavement construction. In this research, shredded plastic waste such as polyethylene (PE) and polypropylene (PP) is added to hot bitumen in different percentages and tested for its effect on strength, durability, and performance characteristics of the road mix. Tests such as penetration test, softening point test, ductility test, and Marshall stability test are conducted. The results indicate that the addition of plastic improves the binding property of bitumen, increases stability, and enhances resistance to water damage. Hence, the use of plastic in road construction not only improves road quality but also helps in solving the problem of plastic waste disposal.

KEYWORDS: Plastic waste, flexible pavement, Reuse, bitumen.

INTRODUCTION

Road construction plays a vital role in infrastructure development. Conventional bitumen roads often fail due to heavy traffic loads, water damage, and temperature variations. Meanwhile, plastic waste such as carry bags, bottles, and packaging materials is increasing

day by day and creates serious environmental problems. To overcome both problems, plastic waste can be used in road construction as a partial replacement for bitumen. Plastic-modified bitumen improves road strength, durability, and resistance to cracks and potholes

The incorporation of plastic into bitumen alters its physical and rheological properties. Plastic acts as a polymer modifier that enhances the binding characteristics of bitumen, making it more resistant to deformation, temperature variations, and water-induced damage. This results in improved performance of roads, including higher strength, better load-bearing capacity, and increased resistance to cracks and potholes.

Several studies and field applications have demonstrated that plastic-modified roads perform better than conventional roads, particularly in regions experiencing extreme weather conditions. Additionally, the use of waste plastic in road construction contributes to sustainable development by reducing environmental pollution, conserving natural resources, and promoting recycling.

METHODOLOGY

1. Bitumen

- Grade used: VG-30 (commonly used for road construction)
- Acts as a binder in flexible pavements

2. Plastic Waste

Types of plastic used:

- Polyethylene (carry bags)
- Polypropylene (food containers)
- PET bottles (after cleaning and shredding)

Plastic is cleaned, dried, and shredded into small pieces of 2–4 mm size.

3. Aggregates

- Coarse aggregate
- Fine aggregate
- Filler (stone dust)

Aggregates are tested for:

- Impact value
- Crushing value
- Water absorption
- Specific gravity

4. Methodology

Step 1: Collection of Materials

Bitumen, aggregates, and waste plastic are collected and prepared.

Step 2: Preparation of Plastic-Modified Bitumen

Plastic is added to hot bitumen at different percentages:

- 2%
- 4%
- 6%
- 8%
- 10%

Step 3: Tests on Bitumen

The following tests are conducted**:**

- Penetration Test
- Softening Point Test
- Ductility Test
- Flash and Fire Point Test

Step 4: Preparation of Bituminous Mix

Marshall specimens are prepared using both:

- Conventional bitumen
- Plastic-modified bitumen

Step 5: Marshall Stability Test

The specimens are tested for:

- Stability
- Flow value
- Density
- Voids in mix

6. PREPARATION OF FLEXIBLE PAVEMENT WITH PARTIAL REPLACEMENT OF BITUMEN WITH PLASTIC

The melted plastic is mixed in different percentages to partially replace bitumen. The melted plastic forms a strong bond with aggregates, increases the binding property of bitumen, and reduces voids in the mix.

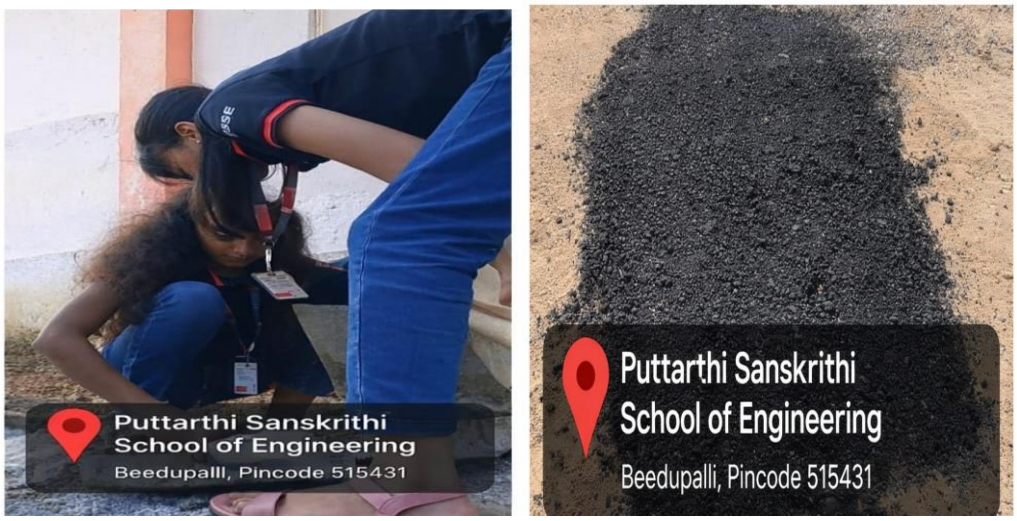

Figure.1. flexible pavement with partial replacement of bitumen with plastic.

7. ANALYSIS OF FLEXIBLE PAVEMENT WITH PARTIAL REPLACEMENT OF BITUMEN WITH PLASTIC :

The following tests are conducted**:**

- Penetration Test
- Softening Point Test
- Ductility Test
- Flash and Fire Point Test

Figure.2. Tests conducted on Flexible pavement.

RESULTS AND DISCUSSION

Experimental Results Showing the Effect of Plastic Addition on Aggregate and Bitumen Properties

The above table presents the results of various laboratory tests conducted to evaluate the effect of partial replacement of plastic in aggregates and bitumen used for road construction. The tests compare the performance of conventional materials with plastic-modified materials at different percentages.

Table.1. Effect of Plastic Addition on Aggregate and Bitumen Properties.

Sl. No	Lab Test	Material Tested	Plastic Content (%)	Approximate Result	Standard Requirement	Remarks
1	Aggregate Impact Test	Aggregate (Normal)	0%	22 %	< 30 %	Acceptable
2	Aggregate Impact Test	Aggregate + Plastic	5 %	18 %	< 30 %	Improved toughness
3	Aggregate Crushing Test	Aggregate (Normal)	0 %	24 %	< 30 %	Acceptable
4	Aggregate Crushing Test	Aggregate + Plastic	8 %	20 %	< 30 %	Better Strength
5	Penetration Test	Bitumen + Plastic	6 %	55 mm	50–70 mm	Normal bitumen
6	Compression test	Bituminous mix with plastic	8 %	3.8 – 4.2 Mpa	3-5 Mpa	Improved

1. Aggregate Impact Test

The Aggregate Impact Test measures the toughness of aggregates, i.e., their resistance to sudden impact or shock.

- For normal aggregates (0% plastic), the impact value is 22%, which satisfies the standard requirement of less than 30%, indicating acceptable quality.
- When 5% plastic is added, the impact value reduces to 18%, indicating improved toughness.
- This shows that plastic coating enhances the ability of aggregates to resist impact loads, making them more suitable for road construction.

2. Aggregate Crushing Test

The Aggregate Crushing Test determines the resistance of aggregates to crushing under compressive loads.

- The crushing value for normal aggregates is 24%, which is within permissible limits

(<30%), indicating acceptable strength.

- With 8% plastic addition, the value reduces to 20%, showing improved resistance to crushing.
- This indicates that plastic improves the load-bearing capacity and strength of aggregates.

3. Penetration Test

The Penetration Test is used to determine the hardness or softness of bitumen.

- For bitumen modified with 6% plastic, the penetration value is 55 mm, which lies within the standard range of 50–70 mm.
- This indicates that the modified bitumen retains suitable consistency while becoming slightly harder and more resistant to deformation.
- The result confirms that plastic addition does not adversely affect the basic properties of bitumen.

4. Compression Test

The Compression Test evaluates the strength of the bituminous mix under compressive loads.

- For the bituminous mix with 8% plastic, the compressive strength ranges between 3.8 – 4.2 MPa, which lies within the acceptable range of 3–5 MPa.
- The increase in compressive strength indicates improved stability and load-bearing capacity of the mix.
- This suggests that plastic-modified bituminous mixes can better withstand traffic loads.

From the table, it is evident that the addition of plastic significantly improves the engineering properties of both aggregates and bitumen. Key observations include:

- **Improved toughness** (lower impact value)
- **Enhanced strength** (lower crushing value)
- **Maintained bitumen consistency** (acceptable penetration value)
- **Higher compressive strength** of the mix

Thus, the results clearly indicate that partial replacement of plastic in bitumen and aggregates leads to better performance characteristics, making it a suitable and sustainable option for road construction was found as 433 mg/L with removal efficiency of 44 %, respectively.

CONCLUSION

- The partial replacement of plastic in bitumen for construction of flexible pavements was analyzed during the study.

- This experimental study proves that waste plastic can be effectively used as a partial replacement of bitumen in road construction. The addition of plastic improves the strength, stability, and durability of bituminous roads. The optimum plastic content is found to be between 6% and 8%.
- Considering the increasing demand for durable roads and the urgent need for effective plastic waste management, this study is essential to evaluate the potential of plastic-modified bitumen as a sustainable and economical solution for modern road construction.
- Therefore, the use of plastic in road construction is both economical and environmentally beneficial

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