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Original Article

Crack Propogation of Plastic Waste Bituminous Mixture Pavement

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Abstract: *This study investigates the effective utilization of plastic waste in road construction to address environmental pollution and improve the durability of road pavements. Plastic waste, including PET, HDPE, and LDPE, was incorporated into bituminous mixtures to evaluate its impact on crack resistance and mechanical properties. The materials were subjected to various tests, including specific gravity, water absorption, abrasion, impact, crushing, penetration, and ductility. The findings indicate that modifying bitumen with up to 15% plastic waste significantly enhances its ductility and stability. Beyond this optimal level, performance deteriorates due to increased brittleness. The study concludes that incorporating plastic waste into bituminous mixes offers a sustainable, eco-friendly solution for flexible pavement construction.*

Keywords: *Plastic waste, Bituminous pavements, Crack resistance, Ductility, Sustainable construction.*

I. INTRODUCTION

In the ever-evolving field of civil engineering, the effective utilization of plastic waste in road construction has emerged as a promising solution to mitigate environmental pollution and enhance pavement durability. With the exponential increase in consumption, plastic has become a significant pollutant, contributing to land and marine degradation, as traditional disposal methods like landfilling and incineration are inadequate and hazardous.

Bituminous pavements are widely used due to their cost-effectiveness and flexibility. However, they are prone to distresses such as cracking, which develops due to thermal stresses, traffic loading, and aging, eventually leading to pavement failure. Recent studies have explored incorporating low-density polyethylene (LDPE), polyethylene terephthalate (PET), and polypropylene (PP) into bituminous mixtures to act as performance-enhancing additives. This polymer network can delay crack initiation and slow down propagation by improving the binder's elasticity and cohesion.

Figure 1: Coarse aggregate

Figure 2: bitumen

Figure 3: Plastic waste

II. MATERIALS AND METHODS

A. Materials

- Bitumen
- Coarse aggregate
- Plastic waste

a) Coarse Aggregate

Crushed stone providing strength, stability, and durability to the structure, ranging in size from 4.75 mm to 80 mm.

Table 1: Specific gravity of coarse aggregate

S.No	Description	Weighing in grams
1	Empty weight of pycnometer (W1)	660
2	Weight of course aggregate in pycnometer (W2)	1127
3	Weight of course aggregate in pycnometer+ 3 Weight of water in pycnometer (W3)	1755
4	Weight of water in pycnometer (W4)	1464

CALCULATION:

Specific gravity of given sample = (W2-W1)/((W2-W1)-(W3-W4))

= (1127-660) / ((1127-660)-(1755-1464))

=2.65

b) Bitumen

A highly viscous hydrocarbon substance used as a binder due to its thermoplastic, adhesive, and waterproofing properties.

Table 2: Penetration test on bitumen

Description	Trial Number		
Penetrometer dial reading	1	2	3
Initial Reading	0	0	0
Final Reading	26	21	18
Penetration value	26	21	18
Mean value		21.67	

c)Plastic Waste

Post-consumer and industrial plastics (PET, HDPE, LDPE, PP, PS) that are cleaned, shredded into 2-4 mm flakes, and processed.

B. Methods

The methodology involves the collection and processing of suitable post-consumer plastics. The plastic waste is incorporated via two primary methods:

1. **Dry Process:** Shredded plastic is mixed with heated aggregates at 160-170°C before adding bitumen.
2. **Wet Process:** Melted plastic is blended directly with the bitumen at 170-180°C.

III. EXPERIMENTAL INVESTIGATION

To assess the quality and suitability of the materials, comprehensive laboratory testing was conducted:

- **Specific Gravity of Coarse Aggregate:** Evaluated using a pycnometer to determine density and porosity.
- **Water Absorption:** Measured by comparing the saturated surface dry weight of the aggregate with its oven-dry weight.
- **Abrasion Value:** Determined using the Los Angeles Abrasion Test to assess resistance to wear and degradation.
- **Aggregate Impact Value (AIV):** Measured the toughness and resistance to sudden shocks or impacts.
- **Aggregate Crushing Value (ACV):** Evaluated resistance to gradual compressive loads.
- **Penetration Test:** Assessed the consistency and hardness of the bitumen at 25°C.
- **Ductility Test:** Measured the elasticity and adhesion properties by stretching a bitumen sample until it breaks.

IV. RESULTS AND DISCUSSION

A. Aggregate Test Results

The coarse aggregate used in the study demonstrated properties suitable for high-performance pavement construction

- The mean specific gravity was calculated as 2.65.

- The mean water absorption was highly favorable at 0.26%.
- The mean abrasion value was determined to be 6.164%.
- The mean aggregate impact value was 12.335%.
- The mean aggregate crushing value was 17.57%.

B. Bitumen Test Results

For the normal bitumen sample, the mean penetration value was 21.67 , and the mean ductility value was 72.9 cm.

C. Performance of Plastic-Modified Bitumen

The incorporation of plastic waste significantly influenced the physical and mechanical properties of the bitumen:

- **Ductility:** The ductility of the bitumen increased with the addition of plastic waste up to 15%, reaching a maximum value of 77 cm, compared to 69 cm for normal bitumen. However, increasing the plastic content further to 20% resulted in a sharp decrease in ductility to 65 cm, indicating increased brittleness.
- **Stability:** The stability value increased from 14.28 kN for normal bitumen to a peak of 15.46 kN at 15% plastic content. At 20% plastic content, the stability dropped to 13.27 kN.

IV. CONCLUSION

The experimental study evaluated the effects of incorporating plastic waste on the performance of bituminous mixtures. The key findings are as follows:

- Modifying bitumen with 15% plastic waste is the optimal content.
- At 15% replacement, the bituminous mix exhibits superior flexibility (77 cm ductility) and stability (15.46 kN), making it more durable and resistant to pavement stresses.
- Beyond the 15% optimum level, performance deteriorates due to the negative effects of excessive plastic.
- This approach provides a highly promising and sustainable solution to manage growing non-biodegradable plastic waste while effectively improving infrastructure quality.

V. REFERENCES

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