

Experimental Study on Plastic Waste as an Additive in Bitumen

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Abstract - The rapid growth of urbanization and industrialization has led to a significant increase in plastic waste generation worldwide. Improper disposal of plastic waste has created severe environmental challenges, including soil pollution, water contamination, and harm to wildlife. At the same time, the construction industry faces issues related to the durability and performance of conventional road materials. This study explores an innovative solution by utilizing plastic waste as an additive in bitumen for road construction. The primary objective of this experimental study is to evaluate the effectiveness of incorporating waste plastic into bitumen and to analyze its impact on the physical and mechanical properties of roads. The study investigates parameters such as strength, durability, resistance to deformation, and water resistance. Various proportions of plastic waste are blended with bitumen, and standard tests such as penetration test, softening point test, and ductility test are conducted to assess performance improvements

Key Words: bitumen, durability, penetration test, softening point test, ductility test, compression test

1. INTRODUCTION

The rapid growth of plastic consumption has led to a significant increase in plastic waste, posing serious environmental challenges due to its non-biodegradable nature. Simultaneously, the demand for durable and cost-effective road construction materials has increased due to urbanization and infrastructure development.

Bitumen, a petroleum-based product, is widely used as a binder in flexible pavements. However, conventional bitumen has limitations such as:

- Temperature susceptibility
- Rutting under heavy loads
- Water-induced damage

To overcome these limitations, plastic waste is used as an additive to modify bitumen. The incorporation of plastic improves the engineering properties of bitumen and enhances pavement performance.

2. Methodology

The bituminous mix consists of:

- Aggregates → 90–95%
- Bitumen → 5–7%
- Plastic waste → 0%, 5%, 10%, 15% (by weight of bitumen)

1. Penetration Test

The penetration test determines the hardness or softness of bitumen by measuring the depth to which a standard needle penetrates the bitumen sample under standard loading and temperature conditions.

Table 1 Penetration Test Result

Plastic Content (%)	Trial 1	Trial 2	Trial 3	Average Penetration (0.1 mm)
0%	65	65	67	66
5%	63	63	64	64
10%	64	59	61	62
15%	57	57	58	58

2. Softening Point Test

The softening point test determines the temperature at which bitumen softens and becomes fluid enough to allow a steel ball to pass through it under specified test conditions.

Plastic Content (%)	Trial 1(°C)	Trial 2(°C)	Average Softening Point (°C)
0%	48	49	48.5°C
5%	52	53	52.5°C
10%	56	57	56.5°C
15%	61	60	60.5°C

3. Ductility Test

The ductility of a bituminous material is measured by the distance in centimeters to which it will elongate before breaking when a briquette specimen.

Sample No.	Plastic %	Trial 1 (°C)	Trial 2 (°C)	Average (°C)
1	0%	48	49	48.5°C
2	5%	52	53	52.5°C
3	10%	56	57	56.5°C
4	15%	61	60	60.5°C

4. Compression Test

The immersion compression test (often ASTM D1075) evaluates the stability and water resistance of bituminous mixtures by measuring the compressive strength of asphalt specimens before and after immersion in water.

Plastic Content (%)	Stability (kN)	Flow (mm)	Bulk Density (g/cc)
0%	8.5	3.2	2.30
5%	10.2	3.4	2.33
10%	11.8	3.7	2.36
15%	10.5	4.1	2.32

3. CONCLUSIONS

From the experimental results, it is evident that the addition of plastic waste significantly affects the engineering properties of bitumen. The penetration values decrease with increasing plastic content, indicating increased stiffness of the binder. The softening point increases, which improves resistance to high temperature conditions.

Although ductility decreases slightly with plastic addition, the values remain within acceptable limits. The Marshall Stability results show a significant improvement in the strength and load-bearing capacity of the mix up to **10%** plastic content.

Therefore, **10%** plastic content provides the optimum balance between strength, stiffness, and flexibility, making it the most suitable proportion for plastic-modified bitumen in road construction.

The use of plastic waste in bitumen not only improves pavement performance but also provides an effective and environmentally friendly solution for managing plastic waste.

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