

# Utilization of Waste Plastic in Flexible Pavement

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**Abstract:** *Plastic waste has become one of the most serious environmental problems due to its non-biodegradable nature and increasing use in daily life. Improper disposal of plastic waste leads to environmental pollution affecting soil, water resources, and ecosystems. This study focuses on the utilization of waste plastic in road construction by modifying bitumen using the wet process.*

*In this method, shredded plastic waste is blended with hot bitumen to produce plastic-modified bitumen. Different types of plastic such as LDPE, HDPE, and PP are used along with bitumen of grades VG-30, VG-40, and VG-50. Plastic is added in proportions of 2%, 4%, 5%, 6%, 7%, and 8% by weight of bitumen.*

*Various laboratory tests such as penetration, softening point, ductility, viscosity, flash point, and fire point are conducted. The results show that penetration and ductility decrease while softening point, viscosity, flash point, and fire point increase with increase in plastic content.*

*The optimum result is obtained at 6% HDPE with VG-30 bitumen. The study concludes that the use of plastic waste in road construction is an economical, eco-friendly, and sustainable solution.*

**Keywords:** Plastic Waste, Bitumen, LDPE, HDPE, PP, Sustainable Construction

## I. INTRODUCTION

Plastic waste has emerged as one of the most serious environmental challenges in recent years due to its non-biodegradable nature and widespread use in daily life. The rapid growth in population, urbanization, and industrialization has led to a significant increase in plastic consumption. As a result, large quantities of plastic waste are generated every year, and improper disposal of this waste leads to severe environmental pollution. Plastic waste accumulates in landfills, water bodies, and open areas, causing harmful effects on soil fertility, aquatic life, and overall ecosystem balance.

At the same time, the construction of roads requires a huge quantity of natural resources and bitumen. Conventional bitumen, although widely used, has certain limitations such as susceptibility to temperature variations, deformation under heavy traffic, and relatively shorter service life. Therefore, there is a need to improve the performance of bitumen while also addressing environmental concerns.

One of the most effective and innovative solutions to these problems is the utilization of waste plastic in road construction. The use of plastic waste in bituminous pavements not only helps in reducing environmental pollution but also enhances the engineering properties of bitumen. The addition of plastic improves strength, durability, resistance to water, and stability of roads, thereby increasing their lifespan and reducing maintenance costs.

Plastic waste can be incorporated into bitumen using two methods, namely the dry process and the wet process. In the dry process, plastic is mixed with aggregates, whereas in the wet process, plastic is directly blended with hot bitumen. In the present study, the wet process is adopted because it provides better bonding between plastic and bitumen and results in a more uniform mixture.

In this study, different types of plastic such as Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), and Polypropylene (PP) are used. These plastics are selected based on their availability, melting characteristics, and



suitability for modification of bitumen. Bitumen of different viscosity grades, namely VG-30, VG-40, and VG-50, is used to evaluate the effect of plastic on different types of binders.

The plastic waste is cleaned and shredded into small pieces of size 2–4 mm before mixing. It is then added to hot bitumen in varying proportions of 2%, 4%, 5%, 6%, 7%, and 8% by weight of bitumen. This variation helps in identifying the optimum percentage of plastic required for improved performance.

To evaluate the properties of plastic-modified bitumen, various laboratory tests are conducted. These include penetration test, softening point test, ductility test, viscosity test, flash point test, and fire point test. These tests help in analyzing the changes in hardness, temperature susceptibility, flexibility, and safety characteristics of bitumen after the addition of plastic.

The main objective of this study is to analyze the effect of waste plastic on the performance of bitumen and to determine the optimum plastic content for road construction. This study also aims to promote sustainable construction practices by utilizing waste materials in an effective manner.

Thus, the use of plastic waste in road construction provides a dual benefit of improving pavement performance and reducing environmental pollution, making it a sustainable and eco-friendly solution for modern infrastructure development.

## II. MATERIALS USED

The materials used in this study include bitumen and waste plastic. Bitumen acts as the binding material in road construction. In this study, three different viscosity grades of bitumen, namely VG-30, VG-40, and VG-50, are used to evaluate the effect of plastic on different grades.



Fig. 1: Bitumen Samples (VG-30, VG-40, VG-50)

Waste plastic is used as a modifier in bitumen. The types of plastic selected for this study are Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), and Polypropylene (PP). These plastics are selected due to their easy availability and suitable properties for mixing with bitumen.



Fig. 2: Waste Plastic (LDPE, HDPE, PP)

Before mixing, the plastic waste is cleaned to remove impurities and then shredded into small pieces of approximately 2–4 mm size. This ensures proper mixing and uniform distribution of plastic in bitumen.





Fig. 3: Shredded Plastic Waste (2–4 mm size)

Plastic is added to bitumen in varying proportions of 2%, 4%, 5%, 6%, 7%, and 8% by weight of bitumen to study its effect on performance.

### III. METHODOLOGY

In the present study, the wet process is used for the preparation of plastic-modified bitumen. In this method, bitumen is heated to a temperature of about 160–170°C until it becomes fluid.



Fig. 4: Heating of Bitumen

After heating, shredded plastic waste of size 2–4 mm is gradually added to the hot bitumen. The mixture is continuously stirred to ensure uniform mixing and proper blending of plastic with bitumen.



Fig. 5: Mixing of Plastic with Bitumen

Different types of plastic such as LDPE, HDPE, and PP are added separately in varying proportions of 2%, 4%, 5%, 6%, 7%, and 8% by weight of bitumen. This helps in studying the effect of different plastic types and percentages on the properties of bitumen.

After proper mixing, the plastic-modified bitumen is prepared and allowed to stabilize. The prepared samples are then used for further laboratory testing.



Fig. 6: Plastic Modified Bitumen Sample

Various tests such as penetration test, softening point test, ductility test, viscosity test, flash point test, and fire point test are conducted to evaluate the performance of the modified bitumen.



**IV. RESULTS AND DISCUSSION**

The performance of plastic-modified bitumen is evaluated using laboratory tests. Due to space limitations, only HDPE modified VG-30 results are presented.

Table 1: Combined Results of HDPE Modified Bitumen (VG-30)

Plastic (%)	Penetration (mm)	Softening Point (°C)	Ductility (cm)	Viscosity (Poise)	Flash Point (°C)	Fire Point (°C)
0%	68	48	75	300	220	240
2%	64	50	70	320	225	245
4%	58	53	65	350	230	250
5%	55	55	60	380	235	255
6%	52	58	55	420	240	260
7%	50	60	50	460	245	265
8%	48	62	45	500	250	270

The results presented in Table 1 show that with the increase in plastic content, penetration value decreases, indicating increased stiffness of bitumen. Softening point, viscosity, flash point and fire point values increase, showing improved thermal stability and safety. However, ductility decreases gradually, indicating reduction in flexibility at higher plastic content.

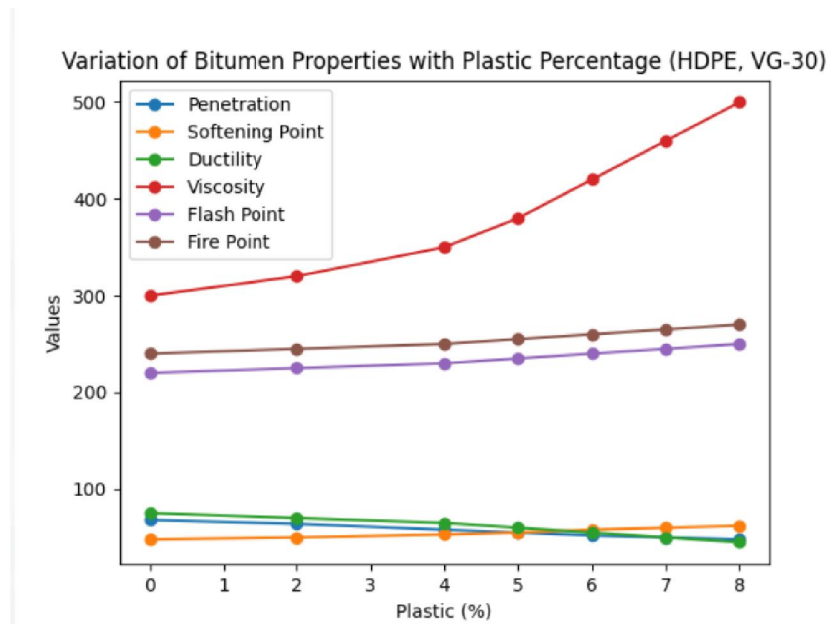


Fig. 7: Variation of Bitumen Properties with Plastic Percentage (HDPE, VG-30)

Fig. 7 clearly shows that as the percentage of plastic increases, penetration decreases while softening point, viscosity, flash point and fire point increase. This indicates that plastic improves the strength and temperature resistance of bitumen.



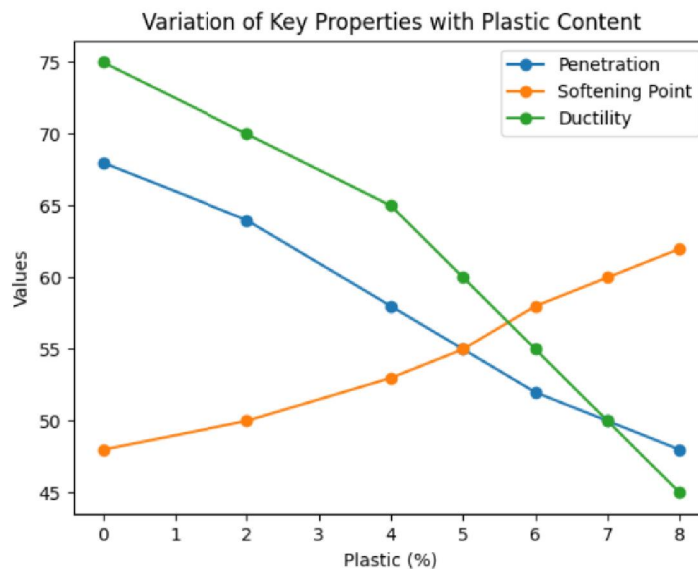


Fig. 8: Variation of Penetration, Softening Point and Ductility with Plastic Content

Fig. 8 shows the variation of key properties of bitumen. It can be observed that penetration and ductility decrease with increase in plastic content, whereas softening point increases. This indicates that bitumen becomes stiffer and more resistant to high temperature.

## V. CONCLUSION

The present study investigates the use of waste plastic in bitumen using the wet process method for road construction. Based on the experimental results, it is observed that the addition of plastic significantly improves the engineering properties of bitumen.

The penetration value decreases with increase in plastic content, indicating improved stiffness and strength. The softening point, viscosity, flash point, and fire point values increase, showing better temperature resistance and safety characteristics. However, ductility decreases gradually with increase in plastic content, but remains within acceptable limits up to 6%.

Among different types of plastic, HDPE shows better performance compared to LDPE and PP due to its higher strength and stability. The optimum plastic content is found to be around 6%, which provides a balanced combination of strength, flexibility, and workability.

Thus, the use of waste plastic in road construction is an economical, eco-friendly, and sustainable solution. It not only enhances pavement performance and durability but also helps in effective disposal of plastic waste, reducing environmental pollution.

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