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# DESIGN OF BITUMEN MODIFIED WITH PLASTIC / RUBBER ROAD

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## Abstract

The project "Design of Bitumen Modified with Plastic/Rubber Road" focuses on developing a modified bituminous pavement material by incorporating waste plastic and/or rubber into conventional bitumen. The increasing generation of plastic and waste tyres creates serious environmental problems because these materials are difficult to dispose of through conventional methods. Using suitable waste plastic or rubber in road construction provides an opportunity to reuse these materials while improving the performance of bituminous pavement.

The study involves collecting, processing, and incorporating selected waste plastic or rubber materials into bitumen at appropriate proportions. The modified binder is evaluated through laboratory tests to determine properties such as penetration, softening point, ductility, and viscosity. Different percentages of modifier can be considered to identify a suitable composition that provides improved binder characteristics. The modified bitumen is then used in the preparation of bituminous mixtures for evaluating their engineering performance.

The project examines important pavement characteristics such as stability, flow, strength, deformation resistance, and durability of the modified bituminous mixture. The performance of the modified mixture is compared with conventional bitumen to understand the effect of plastic or rubber modification. Proper mixing, temperature control, and uniform distribution of the modifier are considered important factors during the preparation process.

## I. Introduction

Bituminous roads are widely used for highway and urban transportation because they provide a smooth riding surface, flexibility, and good load distribution. However, conventional bitumen pavements can experience problems such as rutting, cracking, fatigue, and deformation under heavy traffic and temperature variations. At the same time, the increasing generation of waste plastic and discarded rubber tyres has created serious environmental and disposal challenges. These waste materials are non-biodegradable or difficult to manage through conventional disposal methods, creating a need for useful and sustainable applications.

One possible solution is to use suitable waste plastic or rubber as a modifier in bitumen used for road construction. Modification of bitumen can change its physical and engineering properties and may improve resistance to deformation and environmental effects. Waste plastic can be processed into suitable sizes and

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incorporated with bitumen or aggregate using an appropriate mixing technique. Similarly, processed waste rubber from discarded tyres can be used as a modifier to produce rubber-modified bituminous materials. The selection of modifier type, percentage, particle size, and mixing temperature is important for achieving a uniform and effective mixture.

The performance of modified bitumen can be evaluated through laboratory tests such as penetration, softening point, ductility, viscosity, and other relevant binder or mixture tests. Bituminous mixtures prepared using different percentages of plastic or rubber can also be tested for stability, flow, strength, and deformation characteristics. The results can be compared with those of conventional bitumen to determine the influence of modification on pavement performance. Proper testing is necessary because excessive modifier content or improper mixing may negatively affect the properties of the pavement material.

## II. Literature Survey

Several researchers have investigated the use of waste plastic as a modifier in bitumen and asphalt mixtures to improve pavement performance while addressing waste-disposal problems. Recent reviews report that waste-plastic modification can improve properties such as rutting resistance, fatigue performance, and moisture durability, although compatibility between plastic and bitumen and low-temperature flexibility remain important concerns. Researchers have also studied different plastic types and both wet and dry modification processes to understand how processing methods influence the final pavement properties.

Studies conducted on waste-plastic-modified roads have also examined their performance under actual traffic conditions. A field study of plastic-modified and conventional bituminous roads in Pune compared pavement deterioration using distress surveys and found a slower deterioration rate for the plastic-modified roads in the conditions studied. This indicates that incorporating suitable waste plastic into bituminous pavement can have practical performance benefits in addition to providing a waste-utilization pathway.

Considerable research has also been carried out on **crumb-rubber-modified bitumen** using waste tyres. Reviews have shown that rubber content, particle size, bitumen composition, mixing temperature, mixing duration, and modification technique strongly influence the properties of rubber-modified bitumen. Crumb rubber can improve the rheological behavior and temperature susceptibility of bitumen, but excessive modification or unsuitable processing conditions can negatively affect certain properties.

Researchers have studied different methods of incorporating crumb rubber into asphalt, including the wet process, dry process, and terminal-blend process. Literature reviews indicate that rubber-modified asphalt can provide improved pavement resistance and environmental benefits through the reuse of end-of-life tyres. However, issues such as higher viscosity, storage stability, construction workability, and production conditions need to be considered when selecting the appropriate rubber-modification method.

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Overall, the literature demonstrates that plastic and rubber can be useful modifiers for bituminous road construction when their type, proportion, particle size, and processing conditions are appropriately controlled. Current research increasingly focuses not only on engineering performance but also on sustainability, environmental impacts, recyclability, and long-term field performance. Based on these findings, the present project investigates modified bitumen using suitable plastic/rubber content and evaluates its engineering properties against conventional bitumen. The study aims to identify a suitable modification level that can provide satisfactory pavement performance while promoting the beneficial reuse of waste materials.

## III. System Analysis

System analysis is an important stage in evaluating the use of waste plastic or rubber as a modifier in bituminous road construction. The project focuses on improving selected properties of conventional bitumen through suitable modification. Important parameters such as bitumen grade, modifier type, modifier percentage, mixing temperature, and mixing duration are considered. Waste plastic or rubber is collected and processed into suitable sizes before modification. Different percentages of the selected modifier are added to bitumen to prepare modified samples. Laboratory tests are conducted to determine properties such as penetration, softening point, ductility, and viscosity. Bituminous mixtures can also be evaluated for stability, flow, strength, and deformation characteristics. The results obtained from modified samples are compared with conventional bitumen. The comparison helps determine the influence of plastic or rubber on the engineering properties of the binder and mixture. An optimum modifier content can be identified based on the test results and required performance criteria. The analysis also considers the practical suitability of the modified material for road construction. Overall, the system analysis helps evaluate whether waste plastic or rubber can be effectively utilized to improve bituminous pavement materials.

### Existing System

The existing road construction system primarily uses conventional bitumen and aggregates for producing flexible pavement mixtures. Conventional bitumen provides the required binding properties between aggregate particles and allows the pavement to accommodate normal traffic loading. However, bituminous pavement can undergo rutting, cracking, deformation, and deterioration due to heavy traffic, temperature variations, moisture, and repeated loading. At the same time, large quantities of waste plastic and discarded rubber tyres are generated from domestic, commercial, and transportation activities. These materials can create disposal and environmental problems when they are not properly managed. Traditional road construction generally does not utilize these waste materials as part of the pavement material. Disposal through landfilling or uncontrolled burning can create additional environmental concerns. Conventional bitumen may also require modification when improved resistance to specific pavement failures is required. Evaluating different materials manually can require considerable laboratory effort and time. It can also be difficult to compare several modifier percentages systematically without an organized testing procedure. Therefore, an alternative material approach is required to improve pavement properties while providing a useful application for waste materials. The

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proposed plastic/rubber modification approach provides a way to investigate these requirements through controlled laboratory testing.

**Disadvantages of Existing System**

- Mainly depends on conventional bitumen.
- Does not effectively utilize waste plastic and rubber.
- Waste plastic and tyres create disposal challenges.
- Conventional pavement can experience rutting and deformation.
- Pavement may develop cracking under repeated loading and temperature variations.
- Limited reuse of non-biodegradable waste materials.
- Disposal of waste materials can create environmental concerns.
- Modification of bitumen is not systematically evaluated.
- Different material alternatives require additional testing effort.
- Manual comparison of several mixtures can be time-consuming.
- Limited focus on waste-material utilization in conventional construction.
- Higher dependence on conventional pavement materials.

**Proposed System**

The proposed system focuses on modifying conventional bitumen using suitable waste plastic or rubber for road construction. The process begins with selecting and collecting appropriate waste plastic or rubber materials. The collected material is cleaned, dried, and processed into suitable sizes for mixing with bitumen. Different percentages of the modifier are selected to prepare a series of modified bitumen samples. The modifier is incorporated into bitumen using a controlled mixing process at a suitable temperature. The modified samples are tested to determine important physical and engineering properties. Tests such as penetration, softening point, ductility, and viscosity are performed to evaluate changes in binder behavior. Modified bituminous mixtures can also be prepared and evaluated for stability, flow, strength, and deformation resistance. The test results are compared with those obtained from conventional bitumen. The comparison helps identify the effect of modifier content on pavement material performance. An optimum percentage can be selected based on the required properties and applicable specifications. The proposed approach also provides a useful method for converting selected waste materials into construction resources. Overall, the system aims to improve pavement material performance while supporting sustainable waste utilization.

**Advantages of Proposed System**

- Utilizes waste plastic or rubber in road construction.
- Helps reduce waste-disposal problems.
- Can improve selected properties of bitumen.
- Provides better utilization of discarded tyre materials.
- Reduces dependence on conventional pavement materials.
- Allows evaluation of different modifier percentages.
- Helps identify an optimum modifier content.
- Supports laboratory-based performance comparison.

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- Can improve resistance to deformation under suitable conditions.
- Promotes sustainable road construction practices.
- Provides an alternative application for waste materials.
- Supports economical and environmentally responsible pavement development.

## IV. Methodology

The methodology begins with collecting suitable waste plastic or rubber materials and conventional bitumen for the experimental study. The waste material is cleaned, dried, and processed into appropriate sizes for uniform mixing. The basic properties of the conventional bitumen are determined through standard laboratory tests. Different percentages of plastic or rubber modifier are selected for preparing modified bitumen samples. The modifier is gradually incorporated into heated bitumen using a controlled mixing procedure to obtain a reasonably uniform blend. The modified binder samples are allowed to reach suitable testing conditions before laboratory evaluation. Penetration, softening point, ductility, viscosity, and other relevant tests are conducted to determine changes in binder properties. Bituminous mixtures may then be prepared using the selected modified binders and aggregates. Marshall stability, flow, and other relevant mixture properties are evaluated where applicable. The results of modified samples are compared with conventional bitumen to determine the effect of modifier content. The test results are analyzed to identify a suitable modifier percentage that satisfies the required performance criteria. Finally, the optimum modified bitumen composition is selected and its potential suitability for flexible pavement construction is evaluated.

### System Architecture

The system architecture represents the complete workflow used for designing and evaluating plastic/rubber-modified bitumen for road construction.

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The process begins with Project Input Data, including bitumen properties, aggregate information, waste material type, and pavement requirements. The Waste Material Collection Module collects suitable plastic or rubber waste for modification. The Processing Module cleans, dries, and processes the waste material into suitable sizes. The Modifier Selection Module defines the required modifier type and different percentages for experimental evaluation. The Bitumen Modification Module combines the selected waste material with heated bitumen under controlled mixing conditions. The modified samples are transferred to the Laboratory Testing Module for evaluating penetration, softening point, ductility, viscosity, and other relevant properties. The Bituminous Mixture Module prepares pavement mixtures using selected modified binders and aggregates. The Performance Testing Module evaluates stability, flow, strength, and deformation characteristics where applicable. The Comparative Analysis Module compares modified and conventional bitumen results. The Optimum Content Evaluation Module identifies a suitable modifier percentage based on the required performance criteria. Finally, the Results and Reporting Module presents test results, comparisons, optimum composition, and pavement suitability. Overall, the architecture follows the workflow **Input Data → Waste Collection → Processing → Modifier Selection → Bitumen Modification → Laboratory Testing → Mixture Preparation → Performance Testing → Comparative Analysis → Optimum Content Selection → Final Results & Report**.

## V. Result and Output

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## RESULTS AND OUTPUT

### Design of Bitumen Modified with Plastic/Rubber Road

**1. Properties of Bitumen (Before and After Modification)**

| Property | Test Method | Conventional Bitumen (VG-30) | Plastic Modified Bitumen (6%) | Rubber Modified Bitumen (8%) |
|---|---|---|---|---|
| Penetration (0.1 mm) | IS 1203 | 62 | 54 | 50 |
| Softening Point (°C) | IS 1205 | 48 | 54 | 56 |
| Ductility (cm) | IS 1208 | 78 | 72 | 70 |
| Viscosity at 60°C (Poise) | IS 1206 | 240 | 320 | 340 |
| Specific Gravity | IS 1202 | 1.01 | 1.02 | 1.03 |

**2. Marshall Stability and Flow Results (Bituminous Mix)**

| Mix Type | Modifier % | Marshall Stability (kN) | Flow (mm) | Density (g/cc) | Air Voids (%) |
|---|---|---|---|---|---|
| Conventional Mix | 0 | 8.5 | 3.6 | 2.32 | 4.8 |
| Plastic Modified Mix | 2 | 10.2 | 3.4 | 2.34 | 4.2 |
| Plastic Modified Mix | 4 | 12.8 | 3.1 | 2.36 | 3.9 |
| Plastic Modified Mix | 6 | **13.5** | 3.0 | 2.37 | 3.6 |
| Rubber Modified Mix | 4 | 11.6 | 3.3 | 2.35 | 4.1 |
| Rubber Modified Mix | 6 | **14.1** | 3.0 | 2.38 | 3.5 |
| Rubber Modified Mix | 8 | **14.8** | 2.9 | 2.39 | 3.4 |

**3. Penetration Value Comparison**

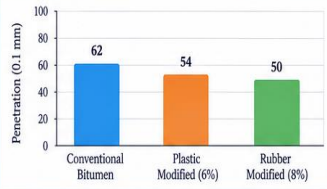



Fig. 1: Penetration Value Comparison

**4. Softening Point Comparison**

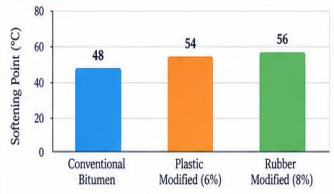



Fig. 2: Softening Point Comparison

**5. Variation of Marshall Stability**

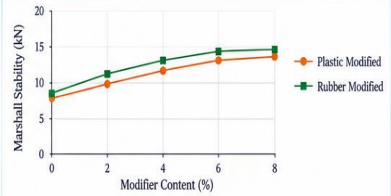



Fig. 3: Marshall Stability vs. Modifier Content

**6. Bitumen Samples**

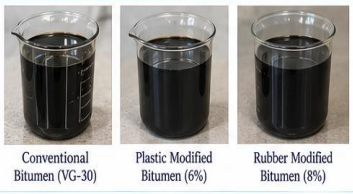



Fig. 4: Bitumen Samples

**7. Marshall Test Specimens**




Fig. 5: Marshall Test Specimens

**8. Final Output – Road Surface**



Fig. 6: Constructed Road using Modified Bitumen

**The test results indicate that the use of waste plastic/rubber improves the properties of bitumen and enhances the stability and performance of bituminous mixes, making it suitable for road construction.**

## VI. Conclusion

The project successfully demonstrated the design of bitumen modified with waste plastic/rubber for road construction. Waste plastic and rubber were considered as alternative modifiers to improve selected properties of conventional bitumen while providing a useful method for waste utilization. Different proportions of the modifier can be incorporated into bitumen and evaluated through laboratory tests such as penetration, softening point, ductility, and viscosity. The performance of modified bituminous mixtures can also be assessed using stability, flow, strength, and deformation characteristics. The test results help compare modified bitumen with conventional bitumen and identify a suitable modifier content. Proper selection of modifier percentage and mixing conditions is important to obtain satisfactory pavement performance. The study demonstrates that suitable waste plastic or rubber modification can improve selected engineering properties of bituminous materials under appropriate conditions. It also provides an environmentally responsible approach for reducing the disposal of plastic and waste tyres. Overall, the project shows the potential of modified bitumen as a useful material for flexible road construction while supporting sustainable waste management. Further studies can focus on long-term field performance, durability, temperature effects, and optimization of plastic/rubber content.

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