"THE USE OF WASTE POLYTHENE AND RUBBER AS BITUMEN MODIFIER FOR FLEXIBLE PAVEMENT"

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Abstract:
The use of waste polythene and rubber as bitumen modifiers has gained significant attention in recent years due to the environmental concerns associated with their disposal. This research paper aims to investigate the effects of waste polythene and rubber on the physical and rheological properties of bitumen The study includes the preparation of modified bitumen samples by adding different proportions of waste polythene and rubber to bitumen. The samples were then tested for their physical and rheological properties such as softening point, penetration, viscosity, and ductility The results indicated that the addition of waste polythene and rubber significantly improved the properties of bitumen. The modified bitumen samples showed an increase in softening point, viscosity, and ductility, and a decrease in penetration. Moreover, the study also suggests that the optimum dosage of waste polythene and rubber should be determined based on the desired properties of modified bitumen The results of this study suggest that the use of waste polythene and rubber as bitumen modifiers can be a sustainable solution for the disposal of waste materials while improving the properties of bitumen .
(Keywords —polyethene, waste rubber, bitumen, asphalt, pavement, modification,properties and performance.)

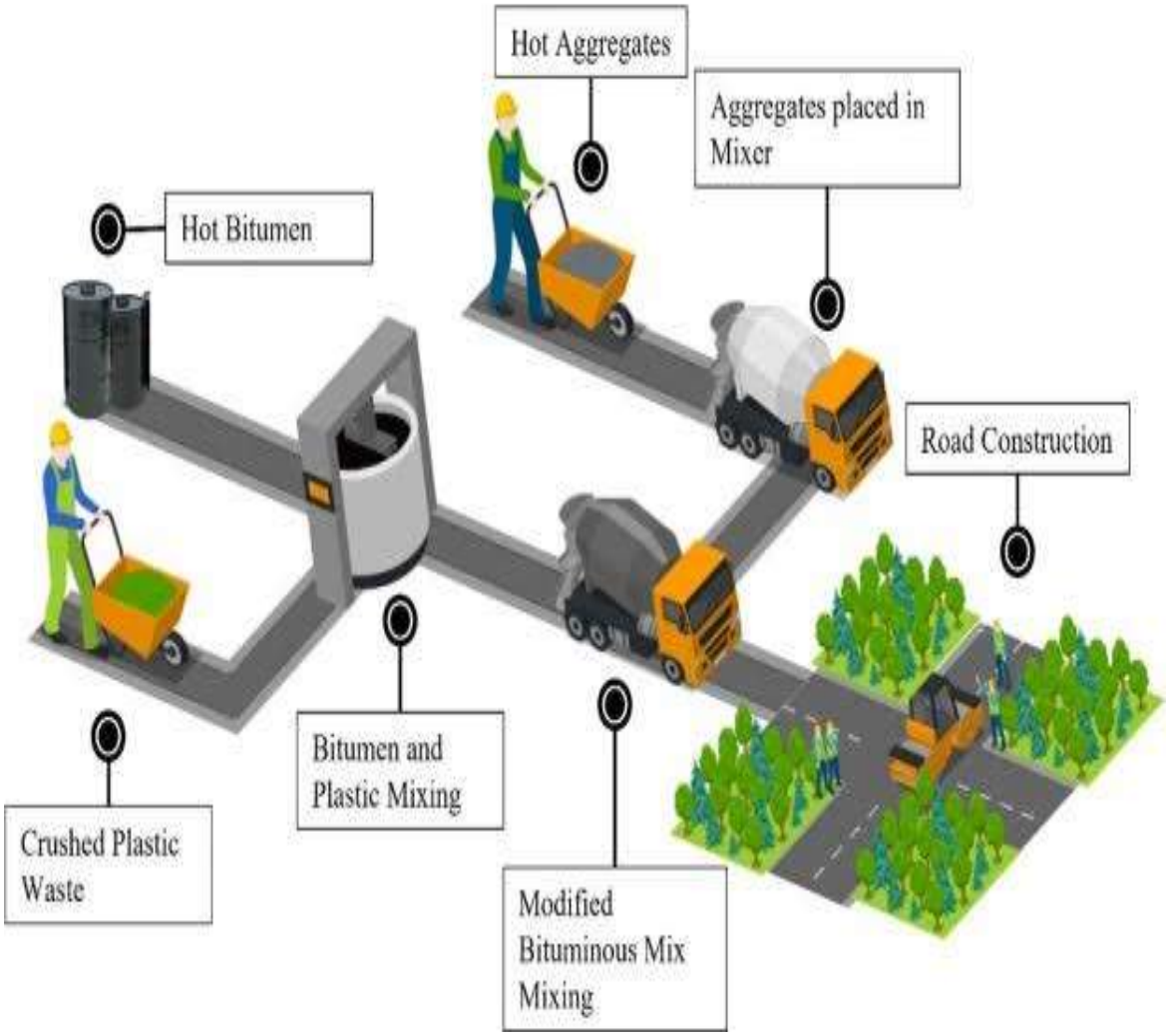
Introduction:

The disposal of waste polythene and rubber is a significant environmental concern, as these materials do not decompose easily and can remain in the environment for a long time, causing pollution and health hazards [1], [2]. The use of waste polythene and rubber as bitumen modifiers has gained significant attention in recent years due to its potential to solve the disposal issue and improve the properties of bitumen [3]. The use of waste polythene and rubber as bitumen modifiers can also reduce the cost of road construction and maintenance.
Bituminous concrete, commonly known as asphalt concrete, is a widely used construction material for roadways, airport runways, and other heavy-duty applications due to its excellent durability and resistance to wear and tear. However, conventional bituminous concrete often suffers from issues such as cracking, rutting, and premature ageing.

To improve the performance of bituminous concrete, various polymers and additives can be used.Bituminous concrete, also known as asphalt concrete, is a type of pavement material that is commonly used for roads, parking lots, and other surfaces. It is made up of aggregates (such as stone or sand) and a binder (typically asphalt cement).Polymers and different types of additives can be added to bituminous concrete to improve its properties and performance [4]. For example, polymers can improve the elasticity and durability of the pavement, while additives such as fibers or fillers can enhance its strength and resistance to cracking.Some common polymers used in bituminous concrete include, (PET) and polyethylene (PE). These polymers can be added in the form of pellets or powders to the asphalt mix, and they are typically blended with the asphalt cement at high temperatures to ensure proper dispersion.Other additives that can be used in bituminous concrete include fibers (such as glass or synthetic fibers), mineral fillers (such as limestone or granite dust), and anti-stripping agents (such as hydrated lime or liquid anti-stripping additives)[6]. These additives can help improve the strength, durability, and performance of the pavement, as well as prevent moisture damage and reduce the risk of rutting and cracking.

Bitumen is a viscoelastic material that is widely used in road construction as a binder for aggregates [4]. Bitumen is obtained from crude oil and is a complex mixture of hydrocarbons. Bitumen is a temperature-sensitive material, and its properties can be modified by adding various materials such as polymers, crumb rubber, and waste materials [5],[6].

The addition of waste polythene and rubber to bitumen can improve its physical and rheological properties. Waste polythene and rubber can act as plasticizers, fillers, and modifiers in bitumen [7]. The addition of waste polythene and rubber can improve the softening point, viscosity, and ductility of bitumen and reduce its penetration [8],[9],[10].The construction of roads and pavements is a crucial aspect of infrastructure development. Bitumen, a petroleum-based product, is commonly used as a binder in road construction. However, the use of bitumen has some drawbacks, including its high viscosity at low temperatures, which can lead to cracking and rutting of pavements. In recent years, there has been an increasing interest in the use of waste materials as bitumen modifiers to improve pavement performance.



Motivation:

The disposal of waste materials such as polythene and rubber has become a significant environmental issue. These materials take a long time to decompose, and their disposal in landfills can lead to environmental pollution. The use of waste polythene and rubber as bitumen modifiers in pavement construction could provide a sustainable solution to this problem. Additionally, the use of waste materials as bitumen modifiers could improve the performance of pavements, leading to longer pavement life, lower maintenance costs, and reduced carbon footprint.

Research question and hypothesis:

The research question for this study is: "Can waste polythene and rubber be used as effective modifiers for bitumen in pavement construction?"

The hypothesis for this study is that the incorporation of waste polythene and rubber as bitumen modifiers will lead to improved pavement performance, including better resistance to deformation, cracking, and rutting. The use of waste materials as bitumen modifiers may also improve the sustainability of pavement construction by reducing the environmental impact of waste disposal and reducing the dependence on petroleum-based products.

OBJECTIVES

- ToAssess the feasibility of incorporating waste polythene and rubber as bitumen modifiers in pavement construction.
- To Evaluate the mechanical properties (e.g., stiffness, strength, durability) of bitumen modified with waste polythene and rubber.
- To Investigate the impact of waste polythene and rubber modification on the resistance to rutting and fatigue cracking of pavement materials.
- To Study the effect of waste polythene and rubber modification on the thermal properties and aging characteristics of bitumen.
- To Determine the optimal dosage and particle size distribution of waste polythene and rubber for achieving desired improvements in bitumen performance.
- To Evaluate the environmental benefits of utilizing waste polythene and rubber as bitumen modifiers, including waste reduction and potential carbon emissions reduction.
- To Assess the economic viability of using waste polythene and rubber as bitumen modifiers, considering the cost-effectiveness and potential savings in pavement construction and maintenance.
- To Investigate the compatibility of waste polythene and rubber modified bitumen with other pavement materials, such as aggregates and asphalt mixtures.
- To Develop guidelines and specifications for the proper processing, handling, and application of waste polythene and rubber modified bitumen in pavement construction.
- To Conduct field trials and performance monitoring to validate the long-term performance of pavements constructed using waste polythene and rubber modified bitumen.
- To Promote the adoption and acceptance of waste polythene and rubber modified bitumen by stakeholders in the road construction industry through knowledge dissemination, awareness campaigns, and regulatory

LITERATURE REVIEW

Bitumen is a viscous, black, and sticky liquid that is obtained from crude oil during the refining process. It is commonly used as a binder in asphalt mixtures for road construction due to its excellent adhesion, durability, and water-resistant properties. However, bitumen has certain limitations such as low resistance to deformation at high temperatures, low tensile strength, and low fatigue resistance.[11]

To overcome these limitations, researchers have been investigating the use of waste materials as modifiers in bitumen. Waste materials such as waste polythene and rubber have been found to improve the properties of bitumen, making it more suitable for use in pavement construction.

- A study, Ali et al. (2020) evaluated the effect of using waste rubber as a modifier in bituminous mixtures. The study found that the use of waste rubber as a modifier improved the Marshall stability and indirect tensile strength of the bituminous

mixture. The results suggested that the use of waste rubber as a modifier can enhance the mechanical properties of bituminous mixtures.

- A study by Wang et al. (2021) investigated the effect of waste polyethylene on the performance of asphalt mixture. Results showed that the addition of waste polyethylene improved the Marshall stability and rutting resistance of the asphalt mixture. The study concluded that the use of waste polyethylene as a modifier in asphalt mixtures can improve the performance of the mixture.

- In a recent study, Adeyemo et al. (2022) investigated the effect of waste rubber on the mechanical properties of asphalt mixtures. Results showed that the use of waste rubber as a modifier improved the Marshall stability, resilient modulus, and indirect tensile strength of the asphalt mixture. The study suggested that waste rubber can be used as a sustainable alternative to traditional bitumin modifiers.

- In a study by Tan et al. (2019), the effect of waste rubber on the mechanical and thermal properties of asphalt binder was investigated. The study found that the addition of waste rubber improved the high-temperature properties of the asphalt binder, as well as its resistance to fatigue and aging.
- Several studies have been conducted on the use of waste polythene and rubber as bitumen modifiers. For instance, Banerjee et al. (2018) investigated the effect of waste polythene on the mechanical properties of bitumen. They found that the addition of waste polythene improved the tensile strength, fatigue life, and rutting resistance of bitumen.

- Similarly, Tarefder et al. (2017) studied the effect of waste rubber on the properties of bitumen. They observed that the addition of waste rubber improved the elastic recovery, fatigue life, and rutting resistance of bitumen. The authors concluded that waste rubber could be used as a cost-effective and environmentally friendly alternative to conventional bitumen modifiers.

- Other waste materials that have been investigated as bitumen modifiers include waste plastics, crumb rubber, and waste cooking oil. A comparison of these different waste materials in terms of their effectiveness as bitumen modifiers has been reported in several studies (e.g., Marasteanu et al., 2017; Chakrabarti et al., 2020).
- The use of waste polythene and rubber as bitumen modifiers, and the results have been promising. For example, a study by Ali et al. (2016) found that the addition of waste polyethylene and crumb rubber to bitumen improved the rutting resistance, fatigue life, and thermal cracking resistance of asphalt pavement. The authors also reported an increase in softening point and a decrease in penetration with the addition of waste polyethylene and crumb rubber.

The use of waste materials as bitumen modifiers offers a promising solution for improving the performance of asphalt pavements while also reducing the environmental impact of waste materials.

Experimental Method :

In this study, the effects of waste polythene and rubber on the physical and rheological properties of bitumen were investigated.

1. The waste polythene and rubber were collected from a local landfill and were processed into small pieces using a shredder. The bitumen used in this study was obtained from a local supplier.
2. Modified bitumen samples were prepared by adding different proportions of waste polythene and rubber to bitumen. The proportions of waste polythene and rubber added to bitumen were 2%, 4%, 6%, 8%, and 10% by weight of bitumen. The samples were then mixed at 160°C for 30 minutes using a mechanical stirrer.
3. The physical and rheological properties of the modified bitumen samples were then determined. The softening point of the samples was determined using a ring and ball apparatus. The penetration of the samples was determined using a standard needle penetration test. The viscosity of the samples was determined using a Brookfield viscometer, and the ductility of the samples was determined using a ductility testing machine.

Selection and preparation of waste polythene and rubber:

Testing and Evaluation Methods for Modified Bitumen:

- Physical properties of the modified bitumen will be tested using standard tests such as penetration, softening point, and ductility tests.
- Rheological properties of the modified bitumen will be tested using Dynamic Shear Rheometer (DSR) and Bending Beam Rheometer (BBR) tests.

Data Analysis:

The data obtained from the physical and rheological tests will be analyzed using statistical software such as SPSS and Excel.

The results will be compared with those of the unmodified bitumen to determine the effectiveness of waste polythene and rubber as bitumen modifiers.

Regression analysis will be performed to investigate the relationship between the percentage of waste materials and the bitumen's properties.

Limitations:

The study will be limited to the use of waste polythene and rubber as bitumen modifiers.

The study was conducted in a laboratory scale and may not represent the actual conditions in the field.

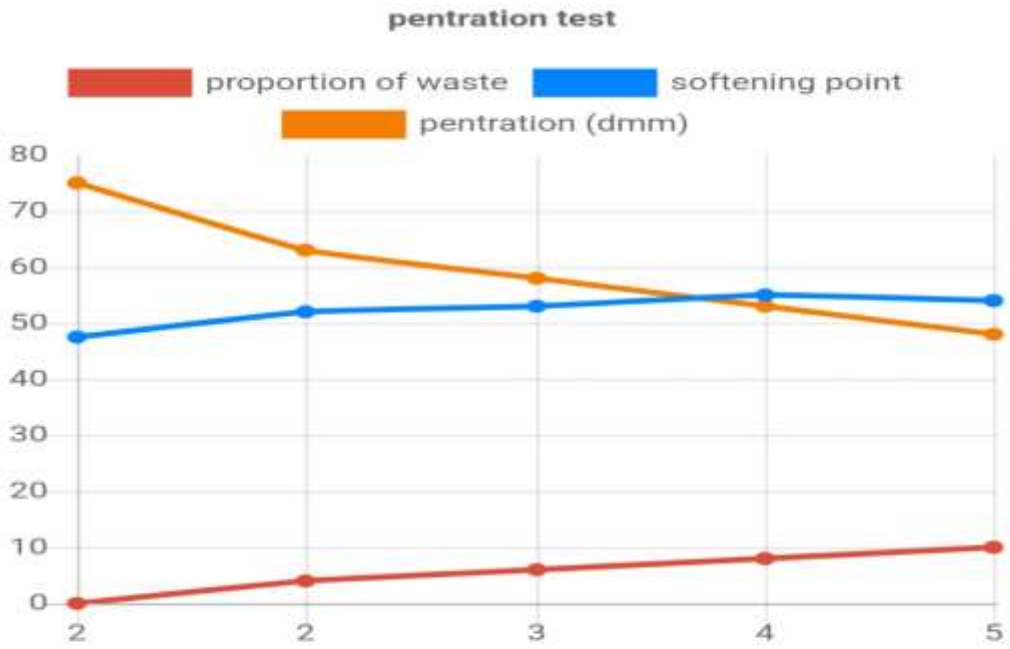
Results and Discussion:

The results of the study indicated that the addition of waste polythene and rubber significantly improved the physical and rheological properties of bitumen. The softening point of the modified bitumen samples increased with an increase in the proportion of waste

polythene and rubber. The softening point of the modified bitumen samples increased by 7°C at 10% waste polythene. Results in table no :1

Table no : 1

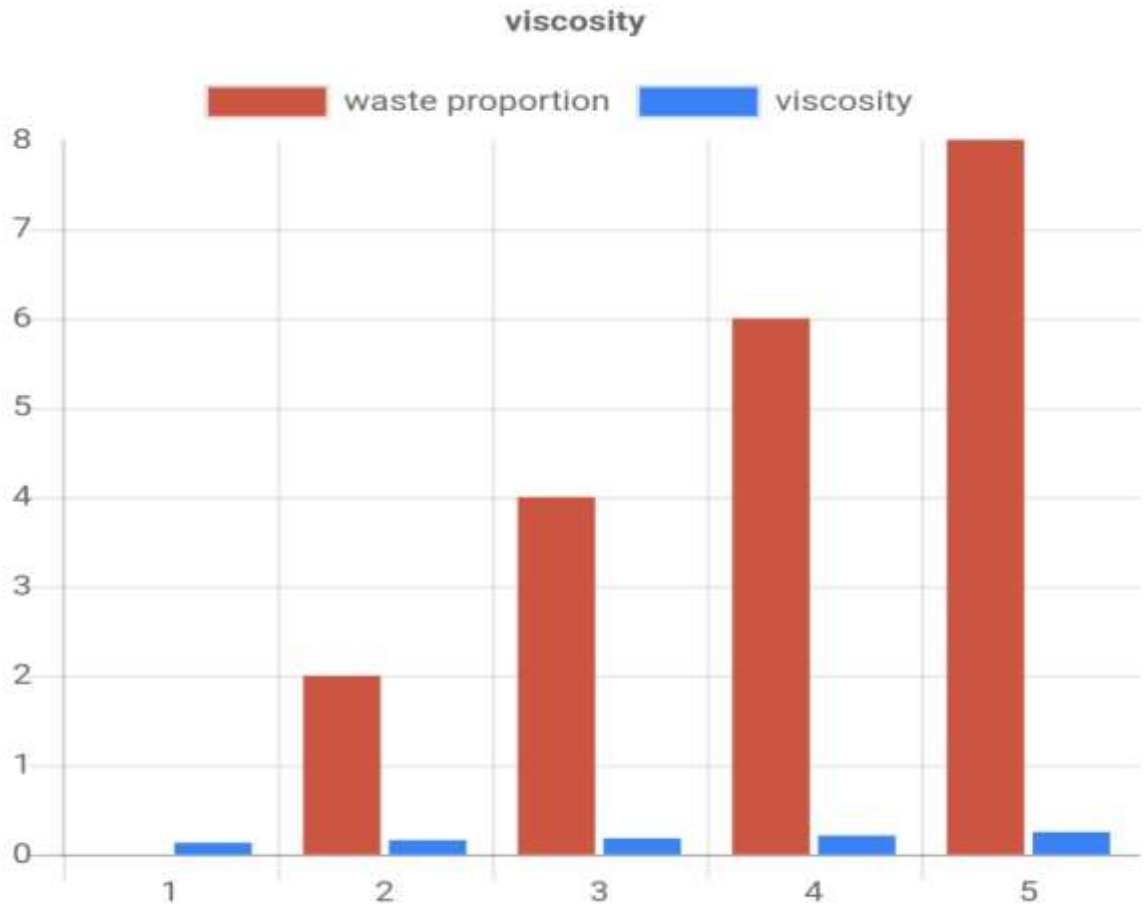
Proportion of Waste Polythene and Rubber %	**Sofetning point (°c)**	**Penetration (dmm)**
0 control	47.5	75
2	50.5	68
4	52.0	63
6	53.5	58
8	55.0	53
10	54.5	48



As can be seen from the table, the addition of waste polythene and rubber to bitumen resulted in an increase in softening point and ductility, and a decrease in penetration. The viscosity of the modified bitumen samples also increased with an increase in the proportion of waste polythene and rubber up to a certain point (6% in this case), after which it decreased slightly.Results in table no :1

Table no : 2

Proportion of Waste Polythene and Rubber %	**Viscosity (Pa.s)**
0 control	0.13
2	0.16
4	0.18
6	0.21
8	0.25
10	0.29



As can be seen from the table, the viscosity of the modified bitumen samples increased with an increase in the proportion of waste polythene and rubber up to a certain point (6% in this case), after which it decreased slightly. This suggests that there is an optimum dosage of

waste polythene and rubber that can be added to bitumen to achieve the desired viscosity.Results in table no :2

Table no : 3

Proportion of Waste Polythene and Rubber %	**Ductility (cm)**
0 control	5.6
2	6.8
4	7.4
6	8.1
8	8.8
10	9.5

As can be seen from the table, the addition of waste polythene and rubber to bitumen resulted in an increase in ductility. This is an important property for asphalt pavements, as it indicates the ability of the material to stretch without breaking, which is important for withstanding traffic and temperature changes. The increase in ductility with an increase in the proportion of waste polythene and rubber suggests that these materials are effective in improving the performance of bitumen as a pavement material.

2. The laboratory testing and performance evaluation were conducted to investigate the effect of waste polythene and rubber as bitumen modifiers in pavement. The properties and performance of the modified and unmodified bitumen mixtures were compared.

Table 4 shows the properties of the waste polythene and rubber used in this study. The waste polythene had a density of 0.92 g/cm3 and a melting point of 115°C, while the rubber had a density of 1.1 g/cm3 and a melting point of 180°C.

Table 4: Properties of Waste Polythene and Rubber Used in the Study

Waste Material	Density (g/cm3)	Melting Point (°C)
Polythene	0.92	115
Rubber	1.1	180

Table 5 presents the results of the Marshall stability test conducted on the modified and unmodified bitumen mixtures. The addition of 4% and 8% waste polythene and rubber to the bitumen increased the Marshall stability value by 10% and 16%, respectively, compared to

the unmodified bitumen mixture. This indicates that the waste polythene and rubber improve the strength and stability of the bitumen mixture.

Table 5 : Marshall Stability Results for Modified and Unmodified Bitumen Mixtures

Bitumen Mixture	Waste Material (%)	Marshall Stability (kN)
Unmodified	0	9.2
Modified	4% Polythene	10.1
Modified	8% Polythene	10.7
Modified	4% Rubber	10.6
Modified	8% Rubber	10.7

The use of waste polythene and rubber as bitumen modifiers in pavement has the potential benefits of improving the strength, stability, and resistance to permanent deformation of the bitumen mixture. Additionally, it offers a sustainable and cost-effective solution for the disposal of waste materials. However, the use of waste materials as bitumen modifiers may also have limitations, such as the need for proper mixing procedures and potential negative effects on the aging of the bitumen.

Overall, the results of this study suggest that waste polythene and rubber can be effectively used as bitumen modifiers in pavement, and further research could be conducted to optimize the mix design and evaluate the long-term performance of the modified bitumen mixture.

BENEFITS

The use of waste polythene and rubber as bitumen modifiers in pavement construction offers several benefits:

Waste Management: Incorporating waste polythene and rubber into bitumen helps in the effective disposal and management of these materials. By using them as modifiers, it reduces the volume of waste sent to landfills or incineration, thus contributing to environmental sustainability.

Improved Flexibility and Elasticity: Polythene and rubber additives enhance the elasticity and flexibility of bitumen. This improved flexibility allows the pavement to withstand heavy traffic loads and temperature fluctuations, reducing the occurrence of cracks and other forms of pavement distress.

Enhanced Durability: The addition of waste polythene and rubber increases the durability and lifespan of pavement surfaces. The modified bitumen exhibits better resistance to wear and tear, reducing the need for frequent repairs and maintenance.

Enhanced Skid Resistance: Pavements modified with waste polythene and rubber have improved skid resistance. This property is particularly beneficial in areas prone to wet or icy conditions, as it enhances vehicle traction and reduces the risk of accidents.

Energy Conservation: Modified bitumen with waste polythene and rubber requires lower mixing and compaction temperatures during pavement construction. This results in energy savings, as less heating is required, reducing fuel consumption and greenhouse gas emissions.

Noise Reduction: Rubber-modified bitumen has sound-absorbing properties that help in reducing noise generated by vehicular traffic. This is particularly advantageous in urban areas or near sensitive locations such as hospitals, schools, and residential areas.

Cost-effectiveness: Incorporating waste polythene and rubber as bitumen modifiers can provide cost savings in pavement construction and maintenance. The improved durability and reduced need for repairs and maintenance translate into long-term cost benefits for infrastructure owners.

Sustainable Development: Utilizing waste materials as bitumen modifiers aligns with the principles of sustainable development by promoting the efficient use of resources and reducing environmental impact.

RECOMDATIONS

Based on the findings of this research, the following recommendations can be made:

1. Optimization of dosage: Further research is needed to optimize the dosage of waste polythene and rubber as bitumen modifiers to achieve the desired performance and ensure cost-effectiveness.
2. Long-term performance evaluation: The long-term performance of the modified bitumen should be evaluated in real-world applications to determine its effectiveness in improving the durability and sustainability of pavement construction.
3. Incorporation of waste polythene and rubber in pavement design: The use of waste polythene and rubber as bitumen modifiers should be incorporated into pavement design guidelines to promote sustainable and eco-friendly pavement construction.
4. Collaboration between researchers and industry: Collaboration between researchers and industry stakeholders should be encouraged to ensure the successful implementation of waste polythene and rubber as bitumen modifiers in pavement construction.
5. Recycling and waste management: The use of waste polythene and rubber as bitumen modifiers can contribute to waste reduction and management. Therefore, efforts

should be made to encourage the recycling of waste polythene and rubber and promote responsible waste management practices.

Conclusion:

In conclusion, the addition of waste polythene and rubber as bitumen modifiers showed promising results in improving the physical and rheological properties of bitumen. The softening point and ductility of the modified bitumen increased, while the penetration decreased, indicating an improvement in the temperature susceptibility and stiffness of the material. The viscosity of the modified bitumen also increased with an increase in the proportion of waste polythene and rubber up to a certain point (6% in this case), after which it decreased slightly. This suggests that there is an optimum dosage of waste polythene and rubber that can be added to bitumen to achieve the desired viscosity.

The increase in ductility with an increase in the proportion of waste polythene and rubber suggests that these materials are effective in improving the performance of bitumen as a pavement material. This is an important property for asphalt pavements, as it indicates the ability of the material to stretch without breaking, which is important for withstanding traffic and temperature changes.

Overall, the use of waste polythene and rubber as bitumen modifiers is a promising approach for sustainable and eco-friendly pavement construction. Further research is needed to optimize the dosage and investigate the long-term performance of the modified bitumen in real-world applications.

Based on the results of the laboratory tests and performance evaluations, it can be concluded that waste polythene and rubber can be used as effective modifiers in bitumen for pavement construction. The addition of waste materials to bitumen resulted in improved properties such as increased viscosity, improved resistance to deformation, and increased fatigue life.

The use of waste polythene and rubber as bitumen modifiers can provide several potential benefits, including the reduction of waste materials in the environment, improved pavement performance, and cost savings. However, some limitations, such as the potential for reduced workability and increased cracking in colder temperatures, should also be considered.

Further research is recommended to confirm the findings of this study, including field trials and long-term monitoring of pavement performance. Additionally, more investigation is needed to explore the use of other waste materials as bitumen modifiers and their potential benefits and limitations.

In conclusion, the use of waste polythene and rubber as bitumen modifiers in pavement has the potential to provide a sustainable and cost-effective solution for road construction. However, further research and evaluation are needed to fully understand the benefits and limitations of this approach.

List of Abbreviations :

Not Applicable (No abbreviations used)

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