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A REVIEW PAPER ON EXPERIMENTAL INVESTIGATION OF WASTE PLASTIC AS A PARTIAL REPLACEMENT FOR BITUMEN IN FLEXIBLE PAVEMENTS

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ABSTRACT

Plastic waste has become a serious environmental problem because of its increasing use and difficulty in natural decomposition.Reducing plastic consumption and recycling or reusing waste plastic is important for controlling this problem. One of the possible ways to reuse waste plastic is its application in road construction.Waste plastic can be processed and mixed with bitumen or other road materials to improve pavement performance.Studies have shown that the addition of suitable plastic waste can improve the strength, durability, and resistance of roads to water and wear.It also provides a useful method for managing plastic waste that would otherwise be dumped or burned. However, the type, quantity, and method of adding plastic must be properly controlled to avoid negative effects on the road and environment.This review paper discusses the different methods of using waste plastic in road construction along with their advantages and limitations.The main aim is to understand how plastic waste can be safely reused while reducing its harmful impact on the environment.Proper use of waste plastic in roads can therefore contribute to both better waste management and more sustainable road construction.

Keywords: Plastic waste, Road construction, Bitumen modification, Flexible pavement, Pavement performance, Waste recycling, Sustainable road construction, Environmental protection, Durability, Plastic waste management

I. INTRODUCTION

Roads are an important part of modern infrastructure and are mainly constructed using materials such as aggregates, bitumen, and other binding materials. They provide safe and convenient transportation of people and goods from one place to another. However, the increasing number of vehicles and changing environmental conditions create a need for roads with better strength and durability. At the same time, the large amount of plastic waste generated every day has become a major environmental concern. Plastic does not decompose easily and its improper disposal can pollute land, water, and the surrounding environment.

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Therefore, proper reuse and management of plastic waste is necessary to reduce its harmful effects.

One possible solution is to use suitable waste plastic in road construction instead of allowing it to become a source of pollution. Waste plastic can be processed and incorporated into bitumen or other road materials in controlled quantities. This can help improve certain properties of roads, such as strength, durability, and resistance to water and wear. At the same time, it provides a useful way of reusing plastic waste and reduces the amount sent to landfills or dumped in open areas. Thus, using plastic waste in road construction can address two problems together plastic waste management and the need for better road materials.This concept can support more sustainable road construction while also helping to protect the environment.



Fig. 1: Workflow of plastic mix bitumen road

II. LITERATURE REVIEW

2.1. Milad et al. (2026): In this research, the authors have investigated the use of waste plastic in asphalt pavement construction in GCC countries. They reviewed pavement performance, research trends and the role of plastic waste in sustainable road construction. The use of plastic waste may help reduce the amount of plastic sent to landfills. Its suitability depends on the plastic type, mixing method and quantity used. Further testing is necessary to assess long-term pavement performance and environmental safety.

2.2. Effect of Mixing Methods on Waste Plastic Modified Asphalt (2026): The authors of this study have provided a comparison between wet and dry mixing methods for waste plastic modified asphalt. They studied the effect of these methods on rutting, stiffness and fatigue performance. The wet method mixes plastic with bitumen, while the dry method adds plastic directly to the asphalt mixture. The choice of method can influence the uniformity and

mechanical properties of the mixture. Suitable laboratory tests are necessary to determine the best method for road construction.

2.3. Added-Value Recycling of Waste Plastics (2026): In this research, the authors have investigated the use of plastic waste to modify asphalt and improve its road performance. They studied plastic content, stability and temperature-related performance of the modified asphalt.Recycling plastic for asphalt can provide an alternative use for discarded materials. The percentage of plastic used can influence the stiffness and stability of the mixture. Proper processing and quality control are important for achieving satisfactory pavement performance.

2.4. Shah, Gao &Abdelfatah (2025): The authors of this study have provided a review of plastic-modified asphalt using different plastic types and mixing methods. They studied mechanical performance, environmental effects and problems such as compatibility and microplastic release. Different polymers may produce different effects on asphalt properties. The compatibility between plastic and bitumen is important for maintaining a uniform mixture. Environmental risks must also be evaluated before plastic-modified asphalt is widely used.

2.5. Ben Ameur, Valentin &Baldo (2025): In this research, the authors have investigated different types of plastic waste used in asphalt mixtures. They compared wet and dry methods and discussed their effects on road performance and sustainability.Different polymers may produce different effects on asphalt properties. The compatibility between plastic and bitumen is important for maintaining a uniform mixture. Environmental risks must also be evaluated before plastic-modified asphalt is widely used.

2.6. Khedaywi, Haddad & Al-Migdady (2025): The authors of this paper discuss that waste polyethylene can be used to modify asphalt binder. They studied the effect of polyethylene content on the properties and performance of asphalt. Polyethylene is commonly available in discarded bags, films and packaging products. Its addition may change the stiffness and temperature-related behaviour of bitumen. The appropriate plastic content must be selected carefully to maintain suitable workability and durability.

2.7. Wu et al. (2025): In this research, the authors have investigated the performance and environmental effects of plastic-modified asphalt. They discussed both the benefits of plastic use and concerns related to microplastics and environmental safety. Plastic modification may improve certain properties of asphalt under suitable conditions. However, the possible release of plastic particles during pavement wear requires attention. Both engineering performance and environmental impacts should be considered before adopting this technique.

2.8. Recycled Plastics in Asphalt Mixtures (2025): The authors of this study have provided a systematic review of recycled plastics used in asphalt mixtures. They compared their mechanical performance, environmental effects and practical use in road construction. Recycled plastics may help reduce the disposal of plastic waste. Their performance depends on the type of polymer and the method of incorporation. Field studies are important for

determining whether laboratory improvements continue throughout the pavement's service life.

2.9. Applications and Environmental Risks of Waste Plastics (2025): The authors of this paper discuss that waste plastic can improve some properties of asphalt but may also create environmental concerns. They reviewed plastic types, mixing methods and possible microplastic formation.The use of waste plastic in roads must be supported by appropriate processing methods. Mixing temperature and plastic content can influence the quality of the final material. Environmental testing is necessary to evaluate possible emissions and plastic particle release.

2.10. Li et al. (2024): In this research, the authors have investigated the use of recycled polyethylene in asphalt. They studied different methods of using polyethylene and its effect on asphalt performance. Recycled polyethylene can be obtained from various discarded plastic products. Its addition may change the consistency and deformation resistance of asphalt. Laboratory testing can help determine suitable proportions and mixing conditions for pavement construction.

2.11. Heydari et al. (2024): The authors of this study have provided an investigation of waste plastic added to asphalt using the dry method. They studied how plastic changes the properties and performance of asphalt binder.The dry method introduces processed plastic directly into the asphalt mixture. The size and quantity of plastic can influence its distribution and performance. Proper mixing and temperature control are important for obtaining uniform mixture.

2.12. Cardoso et al. (2023): The authors of this paper have provided a systematic review of plastic waste used in road pavements. They mainly studied the effect of plastic on rutting and fatigue performance.Rutting occurs when repeated traffic loads cause permanent deformation in pavement. Fatigue cracking develops because of repeated loading over time. Plastic modification must be evaluated for both properties to ensure balanced pavement performance.

2.13. Xiao et al. (2023): In this research, the authors have investigated waste plastic powder as a coating material for aggregates. They studied whether this method can improve the moisture resistance of asphalt mixtures.Moisture damage can weaken the bond between bitumen and aggregates. A suitable coating may help improve the surface characteristics of aggregates. Laboratory testing is necessary to determine whether this method improves durability under wet conditions.

2.14. Xu, Zhao & Li (2022): The authors of this study have provided a review of different waste plastics used as asphalt modifiers. They discussed plastic types, mixing methods, road performance and environmental benefits. Different polymers have different properties and may affect asphalt in different ways. The selection of a suitable plastic depends on the required

pavement performance. Proper evaluation of durability and environmental safety is necessary before practical implementation.

2.15. Abdy et al. (2022): In this research, the authors have investigated the use of pyrolysis products obtained from plastic waste in asphalt road construction. They discussed how plastic waste can be converted into useful materials for roads.Pyrolysis converts plastic waste into products through heating under limited or absent oxygen. Some resulting products may be investigated for use in asphalt materials. Their suitability depends on product quality, processing conditions and environmental considerations.

2.16. Noor &Rehman (2022): The authors of this paper discuss that waste plastic can be used as a modifier in bituminous mixtures. They mainly studied plastic types, mixing methods and improvements in asphalt properties.Waste plastic can change the stiffness and deformation resistance of bituminous mixtures. Different plastic materials may produce different results depending on their properties and quantity. Further testing is needed to assess long term performance under actual traffic and weather conditions.

2.17. Wu & Montalvo (2021): The authors of this study have provided a critical review of waste plastics used in asphalt pavement. They discussed plastic types, mixing methods, pavement performance and environmental concerns.Plastic-modified asphalt may provide a way to reuse discarded plastic materials. Its performance depends on the polymer type, mixing procedure and mixture design. Environmental risks and pavement durability should be assessed together.

2.18. Grady (2021): In this research, the author has investigated the possibility of using waste plastic in asphalt concrete. The study also discussed the economic and practical challenges of using plastic on a larger scale.Using plastic waste in asphalt may reduce the amount of waste requiring disposal. However, collection, sorting and processing require appropriate facilities. Economic feasibility and consistent material quality are important for large-scale construction.

2.19. Ma et al. (2021): The authors of this paper discuss that different types of waste plastic can be used in asphalt through wet and dry processes. They studied their effect on rutting, fatigue and moisture resistance.The wet and dry methods provide different ways of incorporating plastic into asphalt. Rutting, fatigue and moisture resistance are important indicators of pavement performance. The appropriate method should be selected based on laboratory testing and the intended road conditions.

2.20. Heydari et al. (2021): In this research, the authors have investigated the use of waste plastic in asphalt mixtures. They studied different plastic contents and mixing methods and their effect on Marshall properties.Marshall stability and flow tests help evaluate the strength and deformation characteristics of asphalt mixtures. Plastic content can influence both properties. Proper mixture design is necessary to achieve suitable stability without causing excessive stiffness.

2.21. Hassanpour-Kasanagh et al. (2020): The authors of this study have provided an investigation of recycled materials used to modify asphalt binders. They compared recycled modifiers with conventional SBS-modified asphalt. SBS is a polymer commonly used to improve selected properties of asphalt binder. Recycled modifiers are being investigated as possible alternatives or supplementary materials. Their suitability depends on compatibility, mechanical properties and long-term performance.

2.22. Almeida et al. (2020): In this research, the authors have investigated the use of waste LDPE film in asphalt concrete. They studied its effect on stiffness, fatigue, rutting and performance after ageing.LDPE is commonly found in plastic films and packaging materials. Its use in asphalt may influence stiffness and resistance to deformation. Ageing tests are important for understanding whether the modified material retains suitable properties over time.

2.23. Ponnada&Vamsi Krishna (2020): The authors of this paper discuss that waste plastic bottles can be used as a modifier for bitumen. They studied the rheological and Marshall properties of the modified asphalt mixture.Plastic bottles provide a possible source of recyclable material for road construction. Rheological tests help assess the behaviour of bitumen under different loading and temperature conditions. Further testing is necessary to evaluate the durability of the resulting pavement mixture.

2.24. Nizamuddin et al. (2020): In this research, the authors have investigated recycled LLDPE as a modifier for bitumen. They studied how plastic changes the physical and rheological properties of asphalt.LLDPE are used in different packaging products and plastic films. Its addition may change the consistency and flow characteristics of bitumen. Suitable plastic proportions and proper mixing are necessary to achieve a uniform modified binder.

2.25. Brasileiro et al. (2019): The authors of this study have provided a review of recycled polymers used as asphalt modifiers. They discussed materials such as PE, PP and PVC and their effects on asphalt performance.Different polymers have different physical and chemical characteristics. These differences influence their compatibility with bitumen and their performance in asphalt mixtures. Proper material selection and laboratory testing are necessary to determine their suitability for road construction.

2.26. Movilla-Quesada et al. (2019): In this research, the authors have investigated waste plastic added to asphalt mixtures using the dry method. They studied its effect on strength, moisture damage and rutting.The dry method incorporates plastic directly into the asphalt mixture during preparation. Plastic size and content may influence the distribution of material throughout the mixture. Testing is necessary to assess strength, moisture resistance and permanent deformation.

2.27. Dalhat et al. (2019): The authors of this paper discuss that waste plastic can be used as an aggregate replacement or asphalt binder modifier. They studied how these methods affect the

performance of asphalt concrete.Plastic can be incorporated into asphalt in different ways depending on the intended application. Its use as a binder modifier differs from its use as a partial aggregate replacement. Suitable mixture design and testing are necessary to ensure acceptable strength and durability.

2.28. Arulrajah et al. (2017): In this research, the authors have investigated recycled plastic granules along with construction and demolition waste. They studied their strength and stiffness properties for possible construction applications.Construction and demolition waste includes discarded materials such as concrete and bricks. Combining recycled materials may help conserve natural resources and reduce disposal requirements. Their suitability depends on material composition, strength and the intended construction application.

2.29. Dalhat& Al-Abdul Wahhab (2015/2017): The authors of this study have provided an investigation of PP, HDPE and LDPE in asphalt binder. They studied their effect on pavement strength and resistance to deformation.PP, HDPE and LDPE have different physical characteristics that can influence modified bitumen. Their addition may affect binder stiffness and temperature-related behaviour. The appropriate plastic type and content should be selected through laboratory testing.

2.30. Sol-Sánchez et al. (2016): The authors of this paper discuss that waste polyethylene can be used to control cracks in asphalt pavement. They investigated its use as a layer for reducing reflective cracking.Reflective cracking occurs when cracks in an existing pavement appear in a newly constructed overlay. These cracks can reduce pavement durability and allow water to enter the structure. A suitable intermediate layer may help reduce crack propagation, but its effectiveness requires proper testing.

2.31. Ziari, Kaliji&Babagoli (2016): In this research, the authors have investigated the use of waste PET bottles in hot mix asphalt. They mainly studied the effect of plastic content and size on rutting resistance.PET is commonly used in beverage bottles and packaging products. Reusing PET in asphalt may help reduce plastic disposal. The size and percentage of plastic can influence mixture properties, so appropriate proportions must be established through testing.

2.32. Ameri& Nasr (2016): The authors of this study have provided an investigation of PET-modified asphalt. They studied properties such as penetration, softening point and viscosity.Penetration, softening point and viscosity are important properties for evaluating asphalt binder. They help indicate its consistency and behaviour at different temperatures. Additional mixture tests are necessary to determine the suitability of PET-modified asphalt for actual pavement applications.

2.33. Yan et al. (2015): In this research, the authors have investigated asphalt modified with waste rubber and reclaimed LDPE. They studied its rheological properties and temperature performance.Waste rubber and reclaimed LDPE may influence the stiffness and flexibility of asphalt in different ways. Combining recycled modifiers may change the binder's response to

temperature and loading. Appropriate proportions and compatibility testing are necessary to evaluate the performance of the modified material.

2.34. Ahmadzadeh et al. (2015): The authors of this paper discuss that waste polypropylene can be used as an additive in bitumen. They studied its effect on important properties of the bituminous binder.Polypropylene is found in packaging, household products and other discarded plastic materials. Its use in bitumen may provide an additional recycling option. The amount added and the mixing conditions can influence the final binder properties, making laboratory evaluation important.

2.35. Gawande (2013): The author of this study has provided a review of the economic and practical use of plastic waste in road construction. The study discussed how plastic roads can support waste management and road performance.Plastic waste recycling for road construction may help reduce the quantity of waste requiring disposal. It may also provide an alternative use for selected discarded plastic materials. Proper collection, processing and quality control are necessary to ensure suitable road performance.

2.36. Moghaddam, Karim &Soltani (2013): In this research, the authors have investigated waste plastic bottles in asphalt mixtures at different percentages. They studied their effect on Marshall stability and flow.Marshall stability and flow are important parameters for assessing asphalt mixture behaviour. Different plastic percentages may produce different changes in stability and deformation. Appropriate proportions should be selected based on laboratory results and the requirements of the pavement design.

2.37. Moghaddam, Karim &Syammaun (2012): The authors of this paper discuss that waste plastic bottles can be used in Stone Mastic Asphalt. They studied the effect of plastic on stiffness and fatigue behaviour.Stone Mastic Asphalt is designed to provide resistance to deformation under traffic loading. Plastic modification may influence the stiffness and fatigue performance of this mixture. The amount of plastic must be carefully controlled to maintain a suitable balance between stiffness and flexibility.

2.38. Gawande et al. (2012): In this research, the authors have investigated the use of waste plastic in asphalt road construction. They discussed the method of adding plastic to bitumen and its possible benefits.Waste plastic may be processed and incorporated into asphalt using suitable mixing procedures. The plastic type, quantity and mixing temperature influence the quality of the final mixture. Proper testing is necessary to evaluate performance and ensure that the material meets road construction requirements.

2.39. Kalantar, Karim &Abdelaziz (2012): The authors of this study have provided a review of waste and virgin polymers used in pavement construction. They discussed how polymer modification can improve asphalt pavement performance.Polymers can influence the stiffness, elasticity and resistance to deformation of asphalt. Recycled polymers may offer additional

benefits by providing an alternative use for discarded materials. However, their performance depends on compatibility with bitumen and the conditions under which they are incorporated.

2.40. Jeong et al. (2011): In this research, the authors investigated the use of waste polyethylene (WPE) film in flexible pavement materials. They conducted laboratory tests to evaluate the strength, durability, and rutting resistance of plastic-modified asphalt mixtures. The results showed that adding waste polyethylene improved the pavement's resistance to permanent deformation and enhanced its performance. The study demonstrated that waste polyethylene could be a useful alternative to commercial polymer modifiers. The authors concluded that using waste plastic in road construction can improve pavement performance and support plastic waste recycling.

2.41. Al-Hadidy& Tan (2009): The authors of this paper discuss that LDPE can be used to modify asphalt materials. They studied properties such as stability, strength and resistance of modified asphalt.LDPE is commonly found in plastic bags, films and packaging materials. Its addition may change the consistency and deformation behaviour of asphalt. Proper mixing and plastic content control are important for obtaining suitable material properties.

2.42. Huang, Bird &Heidrich (2007): The authors of this study have provided a review of different recycled waste materials used in asphalt pavements. They discussed how these materials can reduce environmental problems and support sustainable road construction.Recycled materials may help conserve natural resources and reduce waste disposal. Their suitability depends on their properties and compatibility with conventional pavement materials. Appropriate testing is necessary to ensure that recycled materials provide satisfactory performance and durability.

III. CONCLUSION

After studying the above reviews we concluded that the use of plastic waste in road construction is a useful method for managing the increasing problem of plastic waste. Plastic waste does not decompose easily and can cause serious pollution when it is not properly disposed. Using suitable waste plastic in roads provides a useful way to reuse this waste instead of sending it to landfills.Studies show that waste plastic can improve the strength and durability of bituminous roads. It can also improve resistance to water, deformation, and wear in suitable conditions. The use of plastic can reduce the amount of some conventional materials required in road construction. It can also help in reducing the environmental problems caused by improper plastic disposal. Different methods such as wet and dry processes can be used to add plastic to road materials. However, the type and quantity of plastic must be properly selected for safe and effective results. Proper mixing and processing are also important to maintain the quality of the road. Therefore, waste plastic can be considered a useful material for more sustainable road construction. It provides benefits for both plastic waste management and road performance. Overall, using waste plastic in roads can be an effective step towards cleaner, stronger, and more sustainable infrastructure.

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