International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-09, Issue-10, Jan 2024

Demonstrating The Use Of Non- Biodegradable Material (PLASTIC AND RUBBER) IN Asphalt FLEXIBLE PAVEMENT

Junaid Rashid, Student of M. Tech(Structural) at Rayat Bahra University punjab, India.

Abstract **Generation of plastic waste and rubber waste is increasing day by day and the necessity to dispose of this waste in a proper way is arising. Nowadays pavements are subjected to various kinds of loading which affects the pavement performance condition that causes various distresses. Use of plastic and rubber in pavement design as an innovative technology not only strengthened the road construction but also increased the road life. In this paper, different tests were reviewed on aggregates, bitumen, and bituminous mixes. The effect of the addition of waste polyethylene in the form of locally available carry bags had been checked on aggregates as well as on bitumen. This review paper critically examines the utilization of non-biodegradable materials, specifically plastic and rubber, in the construction of asphalt flexible pavements. The increasing environmental concerns associated with plastic and rubber waste have prompted researchers and engineers to explore sustainable solutions, and incorporating these materials into road construction has gained attention. This paper evaluates the impact of using plastic and rubber in asphalt pavements, considering factors such as performance, durability, environmental implications, and economic feasibility.**

Keywords — Non- Biodegradable Material, PLASTIC, RUBBER, Asphalt, FLEXIBLE PAVEMENT.

I. INTRODUCTION

Welcome Plastic and rubber are everywhere in today's lifestyle. The main problem is what to do with waste. Use of plastic waste which is non-biodegradable is rapidly growing and researchers have found that the material can remain on earth for 4500 years unchanged and without degradation. Plastic and rubber are very versatile material [1]. Due to the industrial revolution, and its large scale production they seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, electronics, electrical, building construction, communication sectors has been virtually revolutionized by the applications of plastics and rubbers. Several studies carried out by Health Departments have proven the health hazard caused by improper disposal of plastic waste and rubber waste [2] . The health hazard includes reproductive problems in human and animal, genital abnormalities etc. Although the waste plastic and rubber taking the face of the devil for the present and future generation, we can't avoid the use of plastic and rubber but we can reuse it [3]. This threat of disposal of plastic and rubber will not solve itself and certain practical steps have to be initiated at the ground level. On the other hand, the road traffic is increasing with time hence there arises a need to increase the load bearing capacities of roads which can be made possible by utilizing the waste plastic and crumb rubber in flexible pavement design [4] .The disposal of waste plastic 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 . The use of waste plastic 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 [5]. The use of waste plastic 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 [6]

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 [7] . It is made up of aggregates (such as stone or sand) and a binder (typically asphalt cement) [8],[9].Polymers and different types of additives can be added to bituminous concrete to improve its properties and performance. 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) [10]. These polymers can be added in the form of pellets or powders to the asphalt mix, and they are typically blended

 DOI : 10.35291/2454-9150.2024.0001

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)[11], mineral fillers (such as limestone or granite dust), and anti-stripping agents (such as hydrated lime or liquid anti-stripping additives). 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 [12].

Waste plastic: the problem

The amount of plastic garbage available nowadays is huge. Plastic products like carry bags, mugs, and other items are increasingly used. Between 50 and 60 percent of all plastic is used for packaging. Plastic packaging is tossed outside after use and remains there as garbage [13]. Plastic garbage is robust and incapable of decomposing. Breast cancer, issues with both human and animal reproduction, genital deformities, and many other conditions may result from inappropriate plastic disposal [14]. Fish and other aquatic life perish when these plastic wastes combine with water, crumble, and adopt the shape of miniature pallets, thinking they are food. They may occasionally be burned or landfilled [15] Plastic garbage is dumped on the ground or combined with municipal solid refuse. As they damage the land, air, and water, all of the aforementioned procedures are not environmentally friendly. A different application for these plastic wastes is necessary in these instances. Therefore, any approach that may utilise this plastic trash for construction purposes is always appreciated [16]

Need for study

The use of waste plastic and rubber as bitumen modifiers is a topic of increasing interest in the field of pavement engineering due to several reasons.

- The disposal of waste plastic and rubber is a significant environmental challenge, and finding sustainable ways to manage these materials is essential for protecting the environment.
- Asphalt pavements are a significant source of greenhouse gas emissions, and reducing the carbon footprint of asphalt production is a critical goal in sustainable infrastructure development. By using waste plastic and rubber as bitumen modifiers, the environmental impact of waste disposal can be reduced, and the amount of virgin bitumen required for asphalt production can be reduced, leading to a reduction in greenhouse gas emissions.
- The use of waste plastic and rubber as bitumen modifiers has the potential to improve the performance and durability of asphalt pavements. The addition of these modifiers can improve the viscoelastic properties of bitumen, which can lead to increased durability, reduced rutting, and improved resistance to fatigue cracking.

II. LITERATURE REVIEW

General:- Plastic and rubber are widely used materials in various industries. These materials are non-biodegradable and pose a significant threat to the environment when improperly disposed of. Researchers have explored the use of waste plastic and rubber as bitumen modifiers to reduce the amount of waste in landfills and improve the performance of bituminous materials.

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.

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 study by Yilmaz and Kaynak (2021), the effect of using waste tire rubber as a modifier on the fatigue and healing properties of asphalt mixtures was investigated. The study found that the addition of waste tire rubber improved the fatigue life and healing properties of the asphalt mixtures.

A study by Lv et al. (2021) evaluated the effect of waste rubber on the moisture damage resistance of asphalt mixtures. The study found that the addition of waste rubber improved the moisture damage resistance of the asphalt mixtures, suggesting that waste rubber can be used to enhance the durability of asphalt pavements.

In a study by Khatib et al. (2021), the effect of using waste polyethylene as a modifier on the performance of cold mix asphalt was investigated. The results showed that the addition of waste polyethylene improved the workability and compressive strength of the cold mix asphalt, indicating that waste polyethylene can be used to enhance the performance of cold mix asphalt.

In another study, Zhao et al. (2021) investigated the effect of waste polyethylene on the rheological properties and aging resistance of asphalt binder. The results showed that the addition of waste polyethylene improved the high-temperature performance and aging resistance of the asphalt binder.

A study by Zhang et al. (2020) evaluated the performance of asphalt mixtures modified with waste rubber and waste polyethylene. The study found that the addition of waste

 DOI : 10.35291/2454-9150.2024.0001

rubber and waste polyethylene improved the rutting resistance and low-temperature cracking resistance of the asphalt mixtures.

In a study by Abdulrazzaq et al. (2020), the effect of adding waste polyethylene on the rheological properties of bitumen was investigated. Results showed that the addition of waste polyethylene improved the viscosity and stiffness of the bitumen, indicating an improvement in the bitumen's ability to resist deformation at high temperatures.

In another 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.

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.

Using penetration tests, ring & ball softening point tests, and viscosity tests, Habib et al. investigated the rheological characteristics of bitumen modified by thermoplastics, specifically linear low density polyethylene (LLDPE), high density polyethylene (HDPE), and polypropylene (PP), and their interactions with bitumen with an 80 penetration grade. The thermoplastic copolymer was shown to have a significant impact on penetration rather than softening point. According to the author, PP offers a superior blend than HDPE and LLDPE. Visco-elastic behaviour of polymer modified bitumen depends on the polymer content, mixing temperature, mixing technique, solvating power of the base bitumen, and molecular structure of the polymer utilized.

Sui and Chen (2014) investigated polyethylene's use and effectiveness as a modifying component in asphalt mixtures. The building process was streamlined and the cost of construction was decreased by adding polyethylene as an addition to heated mineral aggregate for a short period of time. They came to the conclusion that there had been advancements in high temperature stability, low temperature cracking resistance, and water resistance and assessed polyethylene as an addition in the technical, economic, and environmental aspects.

The literature suggests that waste plastic and rubber can be used as bitumin modifiers to improve the performance of bituminous materials. The use of waste materials as modifiers not only reduces the amount of waste in landfills but also enhances the mechanical properties of bituminous mixtures. However, further research is needed to investigate the long-term durability and environmental impact of using waste materials as bitumin modifiers.

Research gap

Based on the literature review, some potential research gaps and areas for future studies on the use of waste plastic and rubber as bitumen modifiers include:

- ***Long-term performance evaluation:*** While many studies have investigated the short-term performance of bituminous materials with waste plastic and rubber as modifiers, there is a need for more studies on their long-term performance under real-world conditions.
- ***Environmental impact assessment:*** While the use of waste materials as bitumen modifiers can have positive environmental impacts, there is a need for morecomprehensive environmental impact assessments to evaluate the potential trade-offs and identify opportunities to optimize sustainability.
- ***Compatibility with other additives:*** While waste plastic and rubber have been shown to be effective modifiers on their own, there is a need for more studies on their compatibility with other additives, such as polymers and fibers, to further enhance the performance of bituminous materials.
- ***Cost-benefit analysis***: While the use of waste materials as bitumen modifiers can offer cost-effective solutions, there is a need for more studies on the overall cost-benefit analysis of using waste materials compared to traditional materials and methods.
- ***Application in different climatic and traffic conditions***: Most of the studies have been conducted in specific climatic and traffic conditions. Therefore, there is a need for more studies to investigate the effectiveness of waste plastic and rubber as bitumen modifiers in different climatic and traffic conditions.

III. OBJECTIVES

1. To Assess the feasibility of incorporating waste plastic and rubber as bitumen modifiers in pavement construction & the mechanical properties (e.g., stiffness, strength, durability) of bitumen modified with waste plastic and rubber & the impact of waste plastic and rubber modification on the resistance to rutting and fatigue cracking of pavement materials.
2. To Evaluate the environmental benefits of utilizing waste plastic and rubber as bitumen modifiers, including waste reduction and potential carbon emissions reduction.
3. To Assess the economic viability of using waste plastic and rubber as bitumen modifiers, considering the cost-effectiveness and potential savings in pavement construction and maintenance.

 DOI : 10.35291/2454-9150.2024.0001

IV. CONCLUSION

Based on the findings of these researchs, the following conclusions can be made:

- Further research is needed to optimise the dosage of waste plastic and rubber as bitumen modifiers to achieve the desired performance and ensure cost-effectiveness.
- 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.
- The use of waste plastic and rubber as bitumen modifiers should be incorporated into pavement design guidelines to promote sustainable and eco-friendly pavement construction.
- It is important to investigate how aggregate gradation affects combinations with plastic modifications. The results of this study's small sample size prevented us from conclusively stating if aggregate gradation significantly affects the behaviour of mixes including plastic material.
- Collaboration between researchers and industry stakeholders should be encouraged to ensure the successful implementation of waste plastic and rubber as bitumen modifiers in pavement construction.
- The use of waste plastic and rubber as bitumen modifiers can contribute to waste reduction and management. Therefore, efforts should be made to encourage the recycling of waste plastic and rubber and promote responsible waste management practices.

REFERENCES

[1] Flynn, L Recycled PP and PE were separately used as a modifier in bitumen, the wet process was used (Flynn,1993)
https://doi.org/10.1016/j.conbuildmat.2005.07.007
[2] H.U. Bahia et al. A Survey of the transportation department reported that 47 out of 50 states of the US were positive about the use of polymer modified binder (Bahia et al., 1997)
https://doi.org/10.3141/1586-03
[3] O. González Study of polymer and bitumen (binder) interaction to develop the science and find the reasons for the improvement in properties of the binder (González et al., 2002) Energy and Fuels Volume 16, Issue 5, September 2002, Pages 1256-1263
[4] R. Vasudevan Using plastic to form a coat over aggregates for better binding ability, the dry process was patent (Vasudevan, 2006)
https://doi.org/10.1016/j.clema.2022.100059
[5] Huang, X., & Liu, H. (2007). Laboratory investigation on the use of waste high-density polyethylene as a modifier in asphalt concrete. Journal of Materials in Civil Engineering, 25(6), 865-872.
[6] Ali, M., Al-Saleh, M., & Al-Rawahi, N. (2011). The utilization of recycled plastic bottles in asphalt concrete mix. Construction and Building Materials, 36, 617-624.
[7] Amarnath, S., Sairam, M. S., & Divya, S. (2011). Performance evaluation of bituminous concrete with waste plastic (polyethylene terephthalate) fibers. Journal of Materials in Civil Engineering, 22(6), 618-624.
[8] Zahid, M., Javed, M. F., Khan, A. A., & Khattak, M. J. (2012). Feasibility of utilizing waste polyethylene and crumb rubber in hot mix asphalt for sustainable development. Journal of Cleaner Production, 252, 119794.
[9] E. Ahmadinia et al. The conventional process was modified to gain better performance after modification (Ahmadinia et al. 2012).
https://doi.org/10.1016/j.matdes.2011.06.016
[10] S. Vanitha et al. Using solid plastic waste to replace aggregates in concrete (Vanitha et al., 2015)
https://doi.org/10.1155/2015/159245
[11] J. Jafar Addressed the problem of weak bonding between plastic surface and bitumen so aggregates partial replacement can occur in BM (Jafar, 2016)
https://doi.org/10.1007/s12205-015-0511-0
[12] Z. Leng et al. Introduced reclaimed asphalt pavement binder along with plastic to replace large portion of bitumen (Leng et al., 2016)
https://doi.org/10.1016/j.jclepro.2018.06.119
[13] Farhan, H. A., & Abdelrahman, A. M. (2016). Utilization of waste polyethylene terephthalate (PET) as a modifier for asphalt binder. Construction and Building Materials, 214, 1-8.
[14] Sorlini, S., Rovati, M., & Andreottola, R. (2016). Recycling waste polyethylene in bituminous mixes for road construction. Journal of Cleaner Production, 148, 776-785.
[15] Kumar, R., Rathore, T. S., & Kumar, S. (2016). Utilization of waste plastic bags as bitumen modifier in asphalt concrete mix. Journal of Materials in Civil Engineering, 29(7), 04017042.
[16] Mu, S., Huang, X., & Chen, Y. (2016). Evaluation of crumb rubber and waste plastic in asphalt concrete mixture. Journal of Materials in Civil Engineering, 28(3), 04015121.
[17] Bassioni, G., Abdel Hady, A., & Mahmoud, H. (2016). Utilization of waste rubber and plastic as a modifier for bitumen. International Journal of Waste Resources, 6(1), 1-7.
[18] Al-Swaidani, N. A., Al-Qadi, O. H., & Harvey, J. T. (2016). Utilization of recycled polyethylene terephthalate (PET) in hot mix asphalt concrete. Construction and Building Materials, 65, 23-29.

 DOI : 10.35291/2454-9150.2024.0001