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Use Of Recycled Plastic In Asphalt Mixtures For Road Construction

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ABSTRACT

With increasing attention to plastic waste globally, new ideas for recycling have emerged, including utilizing recycled plastics for asphalt mixture in road construction. The objective of this study is to assess the influence of recycled plastics on the performance, environmental sustainability, and cost-effectiveness of asphalt mixtures. In addition, specifically, the research focuses on how various kinds of recycled plastic affect high-temperature performance, low-temperature flexibility, cracking resistance and overall durability. The environmental benefits (reduction of plastic waste and carbon footprint) as well as the economic feasibility of plastic-modified asphalt are also assessed. The results show that recycled plastics like PE and PP have great advantages in improving the high-temperature stability and rutting resistance of asphalt. However, the remaining challenge of low-temperature flexibility and cracking resistance still exists especially with plastic such as polyethylene terephthalate (PET). However, plastic-modified asphalt greatly reduces plastic waste, carbon emissions and long-term costs in maintenance. Taken as a whole, this study represents a path for the use of plastic-modified asphalt as an environmentally friendly option for road construction, improving performance while dealing with environmental concerns that present themselves. Recycled plastics can be further researched to develop optimal blending methods, plastic content, and mixing temperatures to fully reap the benefits of recycled plastics in asphalt mixtures.

Keywords: *Recycled Plastics, Asphalt Mixtures, High-Temperature Performance, Low-Temperature Flexibility Environmental Sustainability, Rutting Resistance, Plastic Waste, Road Construction, Cost-Effectiveness.*

1. INTRODUCTION

Background of the Study

Since the use of recycled plastic in asphalt mixtures has gained much attention in terms of waste management and road construction, it is necessary to assess the various factors affecting the suitability of recycled plastics in incorporation. With plastic waste continuing to pile up all over the world, methods of recycling alternatives are becoming more essential now. Landfilling and incinerating plastic as a means of disposal has several environmental problems and therefore alternative recycling technologies are explored. Reducing environmental pollution by incorporating recycled plastics in asphalt is a potential solution to increase road durability.

Previous work has demonstrated that the inclusion of recycled plastic will improve high-temperature performance and stability (ability to resist rutting and deformation), thus making the asphalt mixture better maintained (Ullah et al., 2024). On the other hand, road projects have also been achieved using waste plastics as modifiers, given that they can afford the construction cost, which means that it is economical (Xu et al., 2021). However, problems such as plastic-type variability and its impact on low-temperature flexibility still exist. Further research is required for the optimum performance of the plastic-modified asphalt mixtures by satisfying these challenges.

Problem Statement

With the ever-rising quantity of plastic waste, the issue is fast becoming a global concern; a large part of plastic waste is polluted by improper disposal methods, as it is landfilled and incinerated. The demand for durable and cost-effective road materials is also increasing at the same time. Due to being a major material in constructing roads, asphalt undergoes modifications so that it can perform better in the construction of roads in all parts of the earth and this project is centered on this aspect. However, asphalt is generally plagued by problems involving rutting at high temperatures and cracking at low temperatures. In the face of such problems, researchers have begun considering the possibility of using recycled plastic in asphalt mixtures to help improve their properties (Xu et al, 2022). However, plastic waste types have variability, plastics are not compatible with asphalt and plastic potential interactions with the environment have not been fully considered (Ma et al., 2021). In addition, despite improvements in the high-temperature performance storages, some issues with the low-temperature flexibility and long-term durability of the plastic-modified asphalt remain. It is important to address these issues for the full ability of reused plastics to serve as materials in road construction.

The aim of this journal is that recycling plastic into asphalt mixtures can improve the asphalt properties including durability, high-temperature performance, and cost-effectiveness, and alleviate the plastic waste problem at the same time. The research objectives are an evaluation of the impact that different types of recycled plastic can have upon high temperature performance of asphalt mixtures. Performance analysis for low temperature flexibility and cracking resistance of asphalt mixtures with incorporation of recycled plastic. For assessing environmental benefits of the application of recycled plastic in asphalt such as the plastic waste reduction and carbon footprint reduction. To compare the performance and cost-effectiveness of plastic-modified asphalt mixtures with traditional asphalt mixtures in road construction projects.

The research questions made are what the effects of are using different types of recycled plastic on the high temperature performance of asphalt mixtures. How does recycled plastic change the low temperature flexibility and cracking resistance of asphalt mixtures? What are the environmental benefits of using recycled plastic in asphalt, particularly in terms of reducing plastic waste and carbon footprint? How do the performance and cost-effectiveness of plastic-modified asphalt mixtures compare to traditional asphalt mixtures in road construction projects?

Significance of the Study

There is significance of this study because it could be used to introduce it in environmental sustainability and materials development for road construction. We are in demand of innovative recycling methods to curb environmental damage due to increased accumulation of plastic waste in the world. Recycled rubber in asphalt (mix) is a solution to reduce plastic waste and improve the properties of asphalt (Hao et al.) Growing environmental concerns about plastic pollution are addressed in this study, and waste plastics offered as a sustainable alternative to landfilling and incineration by bringing waste plastics into the road construction.

It also further develops asphalt technology from the viewpoint of exploring the cost opportunities and improving high temperature stability and durability using plastic-modified asphalt. In particular, these improvements will contribute to reducing problems of rutting and deformation in road surfaces and therefore have high costs and maintenance at large time intervals (Alber et al., 2020). Moreover, such a solution for utilizing recycled plastic in asphalt is evaluated to be economically advantageous since it combines environmental and technical aspects of road construction in this study. Because those could influence the policy decisions regarding the best and most efficient use of recycled materials in construction, the findings could be a basis for more sustainable development of infrastructure in the future.

Scope of the Study

The focus of this study is to assess the potential of recycled plastic in making asphalt mixtures for road construction and the influence of different types of plastic on asphalt performance, environmental benefits, and economic feasibility. This study analyses the effects of polyethylene (PE), polypropylene (PP), or even polyethylene terephthalate (PET) on asphalt mixtures at high and low temperatures for their high-temperature stability, low-temperature flexibility as well as overall durability. Previous work has shown that adding plastic-based materials can greatly enhance the resistance of the asphalt to rutting and deformation, both of which are important pavement characteristics of asphalt surfaces under high traffic and high-temperature environments (Abed and Bahia, 2020). However, some plastics are not compatible with asphalt and the resulting low-temperature performance can be detrimental to asphalt cracking in colder climates.

It also investigates the environmental effects of using recycled plastics in road building: how much plastic waste is decreased and how much carbon belongs to the process of making traditional asphalt. Previous studies have pointed out that using recycled plastics in asphalt is significant from an environmental point of view, as it lowers greenhouse gas emissions and reduces landfill waste. The cost-effectiveness assessment of plastic-modified mixtures compared to conventional mixtures is also included in the scope as reported by various studies indicating potential savings and long-term economic merits (Singh and Gupta, 2024).

2. OBJECTIVES

Plastic Waste and Asphalt Modification

Mass amounts of plastic waste are being produced annually, and the plastic waste crisis is now a major global environmental issue. However, traditional ways of disposal like landfilling and incineration pose a major threat to the environment through soil and water contamination and polluting the air through harmful emissions (Abubakar et al., 2022). Much worse than pollution itself, however, is the fact that so many of these items are uniquely persistent and therefore a waste of ecosystems.

The demand for innovations in recycling plastic waste has been the result of this. Among the promising ways to get the new road construction materials is use of recycled plastic in asphalt mixtures. Asphalt, being a critical road construction material (Rahman et al., 2020), has been improved and is also made more sustainable by adding and modifying various recycled plastics in it. This method is also applicable to increasing the durability and performance of road surfaces, besides minimizing the amount of plastic waste. Recycled plastics can help to improve the high temperature stability, rutting resistance and moisture sensitivity of asphalt mixtures and how much they are viable across traffic and extreme weather issues.

Asphalt modification using recycled plastic is an emerging field of research as it is of global sustainability benefits, and it is suitable for road infrastructure quality improvement. While wider use is possible, the suitability for plastic compatibility and related environmental impacts needs to be overcome.

Recycled Plastics in Asphalt: Types and Characteristics

Over the years, recycled plastics are mixed on asphalt mixtures in order to take advantage of positive effect that plastic waste management performs, and asphalt performance enhancement. Some common types of recycled polymers used in the asphalt modification process are LDPE, HDPE, PET, PP, PS and EVA (Enfrin and Giustozzi, 2022).

Properties of plastic type and properties of the plastic that determine its suitability as an asphalt modifier are affected by physical and chemical properties of the plastic type. For example, LDPE and HDPE have been accepted as flexible and easy to blend with asphalt. It can tolerate a lower crystallinity and melting point (110—120 °C) and is hence more compatible with asphalt in wet processes (Mohammed et al., 2024). HDPE on the other hand has a higher crystallinity (well above 80%) and it is more difficult to incorporate into asphalt than IR/HR as the temperatures are much higher required. PET (melting temperature of 260°C), is usually used in dry processes where a higher rigidity and high-temperature capability are required, but it can be awkward concerning its poor low-temperature flexibility.

PP and PS are incompatible with asphalt in low-temperature environments because of their high crystallinity and in compatibility. In contrast, owing to the balance of rigidity and flexibility of EVA, it is an excellent modifier and has good compatibility with asphalt (Yang et al., 2024). These plastics have different compatibility and performance according as the incorporation method, temperature, and the respective needs of the asphalt mix.

Benefits of Recycled Plastics in Asphalt

Recycled plastics can be used to increase the performance of the asphalt modifier and have environmental advantages and economic savings. In addition, the high-temperature performance and rutting resistance gain are one of the main advantages. Since the main use of asphalt is under heavy traffic stress, especially in a hot climate, it is highly susceptible to deformation. Polyethylene (PE) and polypropylene (PP) used in the plastics recycling industry will also enhance the asphalt's stiffness and high-temperature stability, which would ultimately increase the resistance to rutting (Li et al., 2024). The fact that studies have revealed that plastic-modified asphalt mix refers to conventional asphalt that tends to not last long has made them longer lasting.

The recycled plastics further improve durability and resistance to deformation of asphalt mixtures. Integration of polymers like EVA and HDPE in the asphalt binder and aggregates enhances cohesion between asphalt binder and aggregates leading to better poor overall mixture (Shah, 2024). The life of roads is prolonged and way less maintenance and roads are repaired due to these modified mixtures, which are less prone to cracking and deformation.

There is, however, a problem with plastic-modified asphalt in its effect on the flexibility of its extremely low temperature. The addition of plastics helps to provide better high-temperature properties but also improves stiffness and might cause poor low-temperature flexibility and cracking (Mehta et al., 2024). However, this can be alleviated by getting plastic content and blending procedures joined to achieve the very best overall performance at high temperatures solely just as good as at low temperatures.

An environmental perspective of using recycled plastics in asphalt is that plastic waste is a big source of pollution that is used in asphalt. By recycling plastic into road construction, we not only avoid landfilled waste, but also reduce the carbon footprint in producing new raw materials for any asphalt production. Benmamoun et al., (2024) showed the studies that the employment of waste plastics is less emitting of CO2 gas than conventional asphalt production methods. Additionally, the use of plastic-modified asphalt consumes less energy than traditional methods and thus can save a considerable amount of energy.

Recycled plastics in asphalt also provide cost savings in their production and maintenance. Although the product has a slightly higher initial cost due to processing constraints, it reduces long-term maintenance costs by first increasing the pavement life and second decreasing the repair frequency (Donev and Hoffmann, 2020). Therefore, this is an economically attractive approach to traditional asphalt.

Challenges in Plastic-modified Asphalt

Recycled plastics for asphalt mixtures present several advantages however, various issues should be considered to achieve adequate and long-term sustainable plastic-modified asphalt. However, one major issue is that of the compatibility of different types of plastics with asphalt. Polyethene (PE) and polypropylene (PP) plastics tend to be reasonably compatible with asphalt, which improves the high-temperature performance of asphalt. On the other hand, plastics such as polyethylene terephthalate (PET) and polystyrene (PS) have melting points that are difficult to melt for asphalt binders (Xu et al., 2021). Asphalt is dependent upon a mixture of plastics that have various melting points, especially those that plasticizes only little to zero in hot mixing, which can lead to inconsistent blending and difficulty homogenizing, with an impact on the overall asphalt performance.

It also presents challenges in mixing itself. There are two main methods of using plastics in asphalt, wet and dry. The wet method involves of mixing of plastics with asphalt binder at high temperatures, whereas dry methods recommendations for plastics incorporation for asphalt concrete mixtures involve of direct mix of plastics with aggregate with asphalt binder. Although the wet process creates a more consistent and stable asphalt binder, it is more expensive and requires more specialized equipment (Li et al., 2024). While the dry method is less expensive and easier to implement, the water stability and performance at high temperatures are limited. However, the balance of these methods and the establishment of the most appropriate blending method for different types of plastics is still a challenge. Another is the effect of plastic modification on low-temperature asphalt performance. The increase in stiffness of the asphalt system, through the addition of recycled plastics could cause a reduction of the flexibility of the system at low temperatures and then cracking (Kong et al., 2022). This is a problem, especially in colder climates where roads are likely to be cracked by temperature shifts. The key to the success of plastic-modified asphalt is the finding of the appropriate balancing of low-temperature flexibility with high-temperature stability.

There is a challenge of long-term durability. The disadvantages of plastic-modified asphalt include good resistance to rutting and deformation, but its longevity under severe environmental conditions generates concern. Kumar and Kumar, (2024) indicate that some plastics, such as PVC and PS, can degrade over time and, if failed, may weaken the structural integrity of the asphalt mixture. There have been environmental concerns about some plastics in the past. In the asphalt mixing process, PVC and PS may emit harmful emissions like chlorine and styrene, respectively, which are harmful to air quality and human health (Mnyango and Hlangothi, 2024). However, these environmental risks must be mitigated if plastic-modified asphalt is to be an actual sustainable solution.

Methodologies for Incorporating Plastics into Asphalt

Two methods of incorporating recycled plastics into asphalt include the wet method and the dry method. Advantages and disadvantages exist for each approach; the method of choice mostly depends on whether plastic is used and how it wants the modified asphalt to be.

3. METHODS

Wet Method:
Recycled plastics are combined with the asphalt binder in the wet method at high temperatures of 160-180°C. In this process, the plastics are heated to melting point and are made to mix with the binder uniformly. The wet method has the main advantage of making a homogeneous binder mixture with improved high-temperature stability and rutting resistance (Yang et al., 2024). However, equipment like high-shear mills and higher costs for energy consumption and infrastructure needed are. However, the wet method has the disadvantage of more complicated equipment and the possibility of higher energy consumption. In addition, it requires careful control of the blending conditions, i.e. temperature, time, and shear rate, to achieve a uniform distribution of the plastic in the binder. Depending on the plastic, if it does not melt and distribute properly, the resulting asphalt may not perform properly.

Dry Method:
The recycled plastics are mixed directly with the aggregate before asphalt is added in the dry method. This method is simpler and more cost-effective as it works well in existing asphalt production facilities. From a managerial point of view, the key advantage of the dry method lies in the fact that it requires less specialized equipment and therefore makes it easier to implement on a large scale (Acar et al., 2022). However, the dry method tends to be less well mixed, due to poor mixing of the plastic in the asphalt, hence the poor performance at high temperatures.

Optimal Blending Conditions:
For both methods, these optimal blending conditions are important. Among others, they include controlling the temperature, shear rate, and mixing time. The suitable blending temperature of 170°C and the appropriate shear rate of 3000–4000 rpm is suggested by research for the wet method to obtain adequate dispersion of the plastics (Dharmalingam, 2023). On the other hand, the dry method is very dependent on proper plastic-type and proportion due to the lack of interaction with the aggregates. With different plastic types, both methods have been widely studied. It has been shown by PET and HDPE to perform well in the wet method and LDPE and EVA are best suited to the dry method due to their lower melting points and good compatibility with asphalt.

Case Studies and Real-world Applications
Several case studies from different countries have shown the capacities of plastic-modified asphalt to enhance road performance in a way of treating plastic waste. The application of recycled plastics for road construction in these real-world applications discusses the pluses and minuses that come with these recycled plastics in road construction.

In addition, Plastic modified asphalt has been widely used in India. Plastic waste has been used in the asphalt road mixture since 2002; more than 2,500 kilometers of roads have been built through the dry method (Ogada, 2023). However, even pilot projects like those conducted by the Indian Highway

Congress show that roads get better durability, are far better capable of resisting rutting, and have longer pavement lifespans. There has also been a plastic waste reduction, using plastic in asphalt helping in the challenge of handling increasing plastic waste in the country. However, despite these successes, plastic waste quality could be inconsistent, and special infrastructure for mixing is required to make wider adoption feasible.

UC San Diego, in the United States, made the first asphalt road with a binder made of recycled plastic instead of traditional petrolatum-based bitumen (Xu et al., 2021). It was found to be sustainable and low-cost effective. The use of plastic-modified asphalt brought about improved high-temperature serviceability and reduced maintenance. However, problems with scaling up the technology have been limited by regulatory bottlenecks and concerns about the durability of asphalt containing plastic under the relentless abuse of heavy traffic.

In 1 kilometer of the plastic road project in the Kouga Municipality, about 700,000 plastic bottles have been used (Xu et al., 2021). This project contributes to the success of future applications, showing the possibility of using plastic waste for road construction in low resource settings. However, some of the challenges related with funding and large-scale implementation remain.

In the UK, the company MacRebur, focused on recycled plastic asphalts, has worked on several projects including using recycled plastic to resurface a part of the A689 in Durham (Shopnil, 2022). It demonstrates how plastic-modified asphalt has provided improved durability and a less carbon footprint than would be afforded simply by typical reinforcement with a fiber. The high initial costs and lack of standardization have kept adoption at a large scale from becoming a reality.

However, overall, the technical and environmental advantages of plastic-modified asphalt have been shown in these case studies and additional efforts relating to cost, regulatory approval and plastic consistency will be required for wider adoption. These pilot projects have highlighted lessons learned, the need for more research, improvement in blending techniques, and supportive policies to encourage the widespread use of recycled plastics in asphalt.

Conceptual Framework

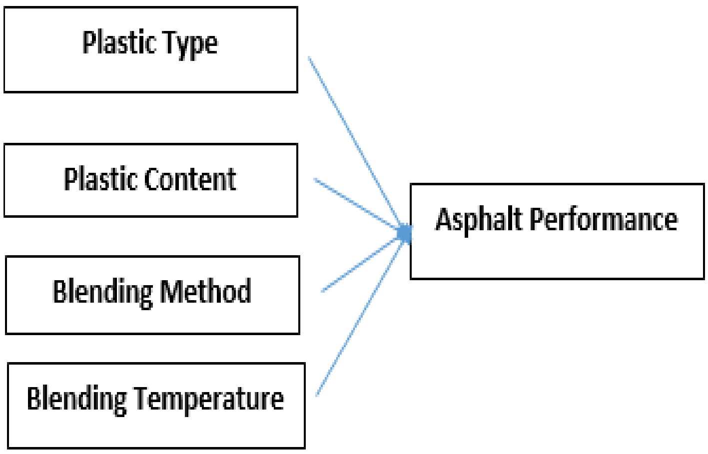


Figure.1. Conceptual Framework

Future Directions and Research Gaps

However, plastic-modified asphalt has demonstrated promising results, research gaps stand between the demonstration of the technology and its full development and deployment in the practice of road construction based on the above-mentioned figure 1, conceptual work Asphalt performance. This one critical area should be further researched on the compatibility of plastic types and asphalt. Different plastics have different physical and chemical properties and hence need to be blended properly to obtain uniform mixtures with long-term durability (Tripathi et al., 2021). Moreover, the plastic type must be investigated and the methods of blending investigated to allow various plastic types. Common plastics like LDPE, HDPE, and PET have been studied before, but other materials, such as biodegradable plastics or mixed plastic waste could lead to something new regarding how to improve asphalt properties. Additionally, it will be important to develop efficient and cost-effective blending techniques that take advantage of the benefits of plastic incorporation.

Low-temperature durability also needs attention as another area. Even with the improvement in high-temperature stability, plastic-modified asphalt still faces limitations in performing at lower temperatures and in freeze-thaw environments. It is needed further research to overcome its flexibility and cracking resistance in cold climate. A final step in the environmental assessment of plastic-modified asphalt should be to perform a complete lifecycle analysis from the perspective of energy consumption, CO_2 emissions, and whether some plastics could be used in producing asphalt with the potential for negative consequences (Diab and Al-Qadi, 2024). These research gaps should be addressed to advance the widespread adoption of plastic-modified asphalt.

Materials and Methods

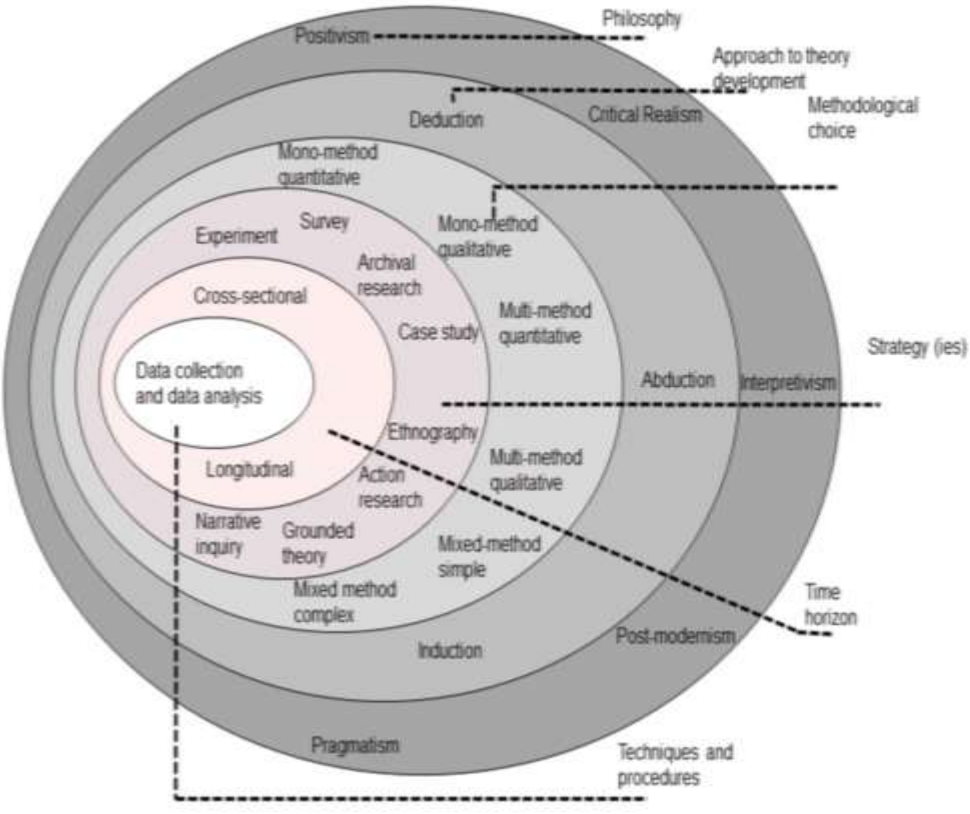


Figure. 2. Research Framework

As shown in the above figure 2, Research opinion is a framework to guide research process composed of layers of philosophy, approach, strategy, choices, time horizons and techniques. It outlines the guidelines as to how the research should be structured in each layer. The research onion approach is applied in the study of the recycled plastics in asphalt mixtures by first positing a positivist philosophy, then conducting a deductive approach, survey strategy and quantitative techniques. The structure allows objectives of the study to align such as performance and environmental impacts to the research methodology. During this report, the methodology for assessing the effect of the use of recycled plastic in the design of asphalt mixtures for road construction is detailed. The study investigates the influence of plastic type, content, the blending method and temperature on the asphalt performance.

The research in these studies is obtained from the positivist philosophy under which reality is considered objective and can be measured and quantified. For this study, positivism is appropriate as the study is intended to quantify the relationship between the independent variables (plastic type, content, blending method, and temperature) and the dependent variable (asphalt performance). It sets a basis for the statistical analysis of the data as the positivist method allows causal inferences to be made based on the evidence of the empirical data (Bateman and Teele, 2024). For the research, this approach is appropriate because it endeavours to investigate and explain the role of different factors in the physical attributes of asphalt.

The research will use a deductive approach where existing theories and literature on plastic-modified asphalt will be used to inform the hypotheses. The existing literature will be reviewed; particularly what various plastic types, contents, and methods of blending do to asphalt properties. These theoretical concepts will serve as bases for collecting the data with a structured questionnaire. The purpose of the testing is to test hypotheses that come from prior studies and to determine how recycled plastics affect asphalt properties in the real world.

The study has adopted a descriptive research design to examine the relationship between independent variables (plastic type, its content, the method of using blending, and temperature) and the dependent variable (that is, asphalt performance). The research adopts a cross-sectional design which collects the data at one time point from a sample of professionals in the road construction industry. Consequently, this design is appropriate to evaluate the perspective regarding attitudes, experiences, and practices about plastic-modified asphalt in an easy and timely way.

The focus will be on the structured questionnaire using the Likert scale to measure plastic-modified asphalt perception by the respondents. Multiple choice questions will be asked in addition to statements on a 5-point Likert scale (1= Strongly Agree, 5= Strongly Disagree). The survey will consider such parameters as the type of plastic employed, type of blending, and plastic-modified asphalt effectiveness. Participants will also be solicited to assess the performance of plastic-modified asphalt on high-temperature stability, low-temperature flexibility, durability, and cost-effectiveness (Mariyappan et al., 2023). Past literature will be used to design the questionnaire and be piloted to make sure it is clear and valid. It is easy to quantify and measure the participant opinions via a Likert scale supporting the quantitative nature of the study.

In this study, a non-probabilistic convenience sampling will be used to pick 150 professionals in the road construction and asphalt production industries. The subjects will be engineers, technicians, and project managers with first-hand experience in the production and modification of asphalt. With the emphasis on professionals who know plastic-modified asphalt, this sampling method is practical. Non-probability sampling is not comparable to representative sampling, yet it is still a great way to obtain collected from a group of people who are important on the subject.

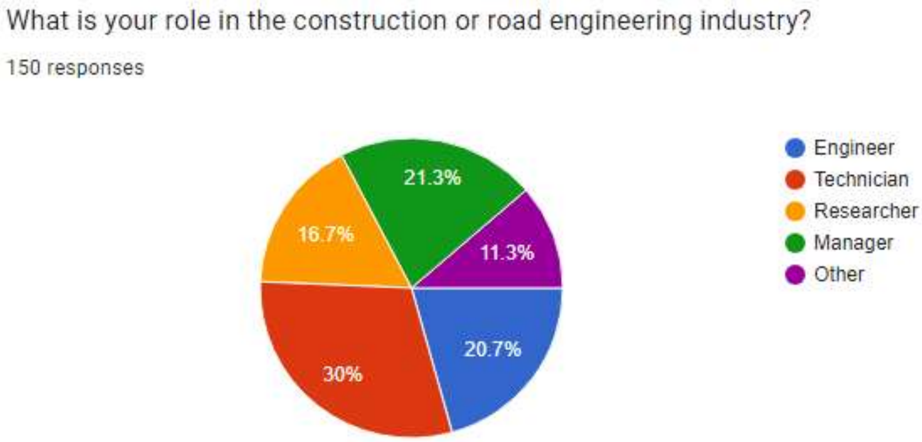
A review of the relevant literature will be the basis on which the questionnaire will be designed and will be pilot tested to ensure clarity. Participants will be distributed electronically through email from the questionnaire. To facilitate data collection, we will use online survey platforms such as Google Forms to disseminate and obtain data. Professional networks, industry conferences, and online forums of road construction will be the sources of participants. Informed consent is obtained from each participant, and the purpose of the study is explained. It should take about 10 – 15 minutes to complete the survey and participants will be asked to do so. If necessary, follow-up emails will be sent to the participants to complete the survey. The responses will be checked for completeness and any incomplete or inconsistent responses will be excluded from the analysis, at this stage.

SPSS (Statistical Package for the Social Sciences) is suitable for quantitative analysis and the performance of tests such as correlation, regression, frequency analysis, etc. by analyzing the data. The demographic data and each item of the questionnaire will be summarized through frequency analysis. To compare the relationship between the independent variables (plastic type, content, blending method, and temperature) and the dependent variable (asphalt performance), we will use Pearson's correlation coefficient. The predictive power of the independent variables on asphalt performance will be assessed using multiple regression analysis accounting for potential confounding factors. Internal consistency of the measure is measured using Cronbach's alpha to assess the reliability of the Likert scale items.

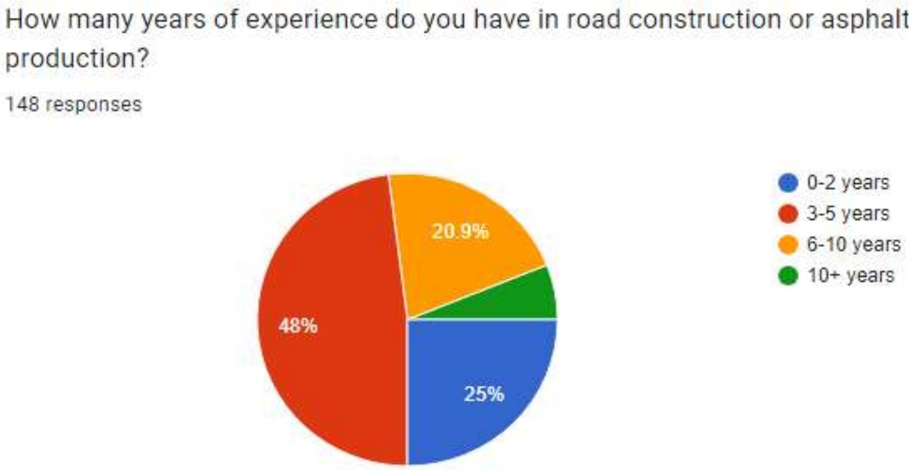
Ethical considerations always remain the top priority during the study. All participants will have informed consent obtained so that they will understand the purpose of the study and the right to confidentiality. Participation will be promised that responses will remain anonymous, and data will be used for research only. Ethical guidelines are going to allow participants to withdraw their participation at any time, there will be no harm done. The data will be safeguarded and analyzed in accordance the ethical research standards.

4. RESULTS AND FINDINGS

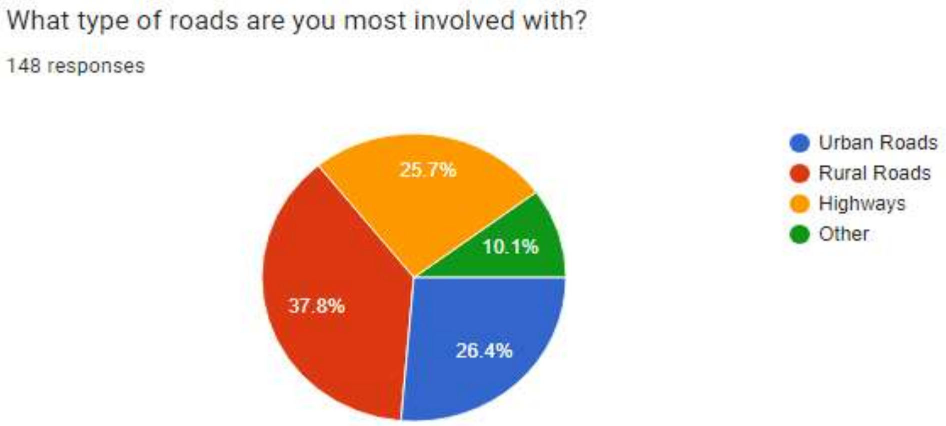
Demographic Analysis



The survey sample contains professionals in the road engineering industry as well as in the construction and other related fields. The largest group (30%) is technicians, engineers (20.7%), managers (21.3%), and researchers (16.7%). Of these, only 11.3 percent are identified as "other" because different outlooks of the industry are incorporated in this section as well.



A moderately experienced workforce (48%) is indicated by the fact that most respondents (72%) have 3 to 5 years of experience in road construction or asphalt production. The group is quite young as a significant portion (25 percent) has 0–2 years of experience, whereas few have 6–10 years (20.9 percent) or more than 10 years (6.1 percent).



Rural roads are most involved with by majority (37.3%), followed by urban roads (26%) and highways (26%). By having other types of roads as its focus (10.7%), a smaller portion work for roads other than rural infrastructure, which seem to be the most predominant area of engagement.

Table 1: Frequency Analysis

		Count	N %
What is your role in the construction or road engineering industry?	Engineer	31	20.7%
	Technician	45	30.0%
	Researcher	25	16.7%
	Manager	32	21.3%
	Other	17	11.3%
How many years of experience do you have in road construction or asphalt production?	0-2 years	37	25.0%
	3-5 years	71	48.0%
	6-10 years	31	20.9%
	10+ years	9	6.1%
What type of roads are you most involved with?	Urban Roads	39	26.0%
	Rural Roads	56	37.3%
	Highways	39	26.0%
	Others	16	10.7%
The type of plastic used in asphalt mixtures significantly affects its high-temperature performance.	Strongly Disagree	4	2.7%
	Disagree	12	8.1%
	Neutral	33	22.1%
	Agree	60	40.3%
	Strongly Agree	40	26.8%
Certain plastics, such as HDPE, are more compatible with asphalt than others.	Strongly Disagree	6	4.0%
	Disagree	11	7.3%
	Neutral	25	16.7%
	Agree	68	45.3%
	Strongly Agree	40	26.7%
The use of PET in asphalt mixtures leads to better overall performance than other plastic types.	Strongly Disagree	7	4.7%
	Disagree	12	8.0%
	Neutral	40	26.7%
	Agree	55	36.7%
	Strongly Agree	36	24.0%
The type of plastic chosen for asphalt modification impacts its ability to resist rutting.	Strongly Disagree	13	8.7%
	Disagree	17	11.3%
	Neutral	37	24.7%

	Agree	47	31.3%
	Strongly Agree	36	24.0%
Increasing the percentage of plastic in asphalt improves its rutting resistance.	Strongly Disagree	10	6.7%
	Disagree	23	15.4%
	Neutral	27	18.1%
	Agree	57	38.3%
	Strongly Agree	32	21.5%
Higher plastic content enhances the durability of asphalt mixtures.	Strongly Disagree	5	3.3%
	Disagree	19	12.7%
	Neutral	36	24.0%
	Agree	60	40.0%
	Strongly Agree	30	20.0%
The addition of more plastic leads to increased stiffness in asphalt, improving its high-temperature performance.	Strongly Disagree	8	5.4%
	Disagree	11	7.4%
	Neutral	36	24.2%
	Agree	61	40.9%
	Strongly Agree	33	22.1%
A higher percentage of plastic in asphalt decreases its low-temperature flexibility.	Strongly Disagree	7	4.7%
	Disagree	22	14.8%
	Neutral	29	19.5%
	Agree	60	40.3%
	Strongly Agree	31	20.8%
The wet method of blending plastic with asphalt produces a more uniform mixture than the dry method.	Strongly Disagree	9	6.0%
	Disagree	17	11.3%
	Neutral	28	18.7%
	Agree	63	42.0%
	Strongly Agree	33	22.0%
The dry method of blending is more cost-effective compared to the wet method.	Strongly Disagree	8	5.3%
	Disagree	17	11.3%
	Neutral	32	21.3%
	Agree	46	30.7%
	Strongly Agree	47	31.3%
The wet method of plastic incorporation leads to better compatibility between plastic and asphalt.	Strongly Disagree	7	4.7%
	Disagree	16	10.7%
	Neutral	34	22.7%
	Agree	63	42.0%
	Strongly Agree	30	20.0%
The dry method results in lower-quality asphalt mixtures compared to the wet method.	Strongly Disagree	8	5.3%
	Disagree	11	7.3%
	Neutral	42	28.0%
	Agree	60	40.0%
	Strongly Agree	29	19.3%
Higher blending temperatures improve the dispersion of plastic in asphalt mixtures.	Strongly Disagree	10	6.7%
	Disagree	12	8.1%
	Neutral	39	26.2%
	Agree	45	30.2%
	Strongly Agree	43	28.9%
The optimal blending temperature for plastic-	Strongly Disagree	8	5.3%
	Disagree	16	10.7%

modified asphalt is between 160Â°C and 180Â°C.	Neutral	43	28.7%
	Agree	49	32.7%
	Strongly Agree	34	22.7%
Higher temperatures lead to better integration of plastic into the asphalt binder.	Strongly Disagree	8	5.4%
	Disagree	19	12.8%
	Neutral	38	25.7%
	Agree	50	33.8%
	Strongly Agree	33	22.3%
The temperature used for blending significantly impacts the final properties of plastic-modified asphalt.	Strongly Disagree	9	6.0%
	Disagree	22	14.7%
	Neutral	39	26.0%
	Agree	49	32.7%
	Strongly Agree	31	20.7%
Plastic-modified asphalt has better high-temperature stability compared to traditional asphalt.	Strongly Disagree	10	6.7%
	Disagree	17	11.4%
	Neutral	34	22.8%
	Agree	53	35.6%
	Strongly Agree	35	23.5%
The use of recycled plastics in asphalt increases its resistance to rutting under heavy traffic conditions.	Strongly Disagree	3	2.0%
	Disagree	13	8.7%
	Neutral	38	25.5%
	Agree	57	38.3%
	Strongly Agree	38	25.5%
Plastic-modified asphalt is more durable and requires less maintenance over time.	Strongly Disagree	9	6.0%
	Disagree	14	9.3%
	Neutral	42	28.0%
	Agree	56	37.3%
	Strongly Agree	29	19.3%
Plastic-modified asphalt performs better at low temperatures and reduces cracking.	Strongly Disagree	6	4.0%
	Disagree	13	8.7%
	Neutral	44	29.5%
	Agree	57	38.3%
	Strongly Agree	29	19.5%
Plastic-modified asphalt mixtures are more sustainable compared to conventional asphalt due to reduced plastic waste.	Strongly Disagree	9	6.1%
	Disagree	10	6.8%
	Neutral	35	23.6%
	Agree	60	40.5%
	Strongly Agree	34	23.0%

In the table1, frequency analysis of responses investigated professionals in road construction and asphalt production, particularly when recycling plastics were used in the making of asphalt mixtures. The sample is of a heterogeneous group that includes technicians (30%), engineers (20.7%), and managers (21.5 %). The distribution of this contains a good balance of practical, technical, and managerial approaches toward the topic. Almost half of the respondents were experienced with 3 to 5 years of experience, implying moderate experience with the asphalt production process, which could suggest a good grasp of plastic-modified asphalt. A large number of respondents (40.3%) agree that the type of plastic used in asphalt mixtures has a positive effect on its high-temperature performance and 26.8% agree strongly. This backs up the hypothesis that certain plastic types like HDPE and PET are frequently believed to improve the asphalt's durability at high temperatures. HDPE is also more compatible with asphalt (agreed by a majority of (45.3 percent agree and 26.7 percent strongly agree) which is consistent with findings that plastics with higher crystallinity, such as HDPE, generally mix better with the asphalt binder.

Increasing the plastic in the asphalt usually works well for the asphalt, according to respondents. For instance, 38.3 percent concur, and 21.5 percent strongly concur that greater plastic content improves rutting resistance. Moreover, 40 percent of respondents agree that a higher percentage of plastic is likely to increase durability, and 40.3 percent confirm that a higher percentage of plastic would reduce low-temperature flexibility. These findings emphasize the trade-off of better high-temperature stability with the threat of poor low-temperature cracking. Of the respondents who evaluate blending methods, a large majority (42% agree, 22% strongly agree) understand that the wet method results in more uniform mixtures than the dry method. 30.2% agreed and 28.9% strongly agreed that higher blending temperatures provide a vast improvement to the dispersion of plastics in asphalt. The results point to the need for the proper method and temperature to optimize plastic-modified asphalt performance. Analysis shows that most respondents that respondents thought plastic-modified asphalt is better than traditional asphalt, especially in terms of high-temperature stability, rutting resistance, durability and sustainability. In particular, 23.5% agree and 35.6% strongly agree that plastic-modified asphalt provides better high-temperature stability and 37.3% agree that plastic-modified asphalt reduces maintenance requirements as time passes. Interestingly, not only do 307 survey participants agree (40.5%) and strongly agree (23.0%) that plastic-modified asphalt is less wasteful than normal asphalt; it is more sustainable as plastic wastes are recycled into asphalt mixtures.

Table 2: Correlations Analysis

Correlations						
		Plastic Type	**Plastic Content**	**Blending Method**	**Blending Temperature**	**Asphalt Performance**
Plastic Type	Pearson Correlation	1	.593**	.558**	.546**	.517**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001
	N	150	150	150	150	150
Plastic Content	Pearson Correlation	.593**	1	.646**	.643**	.581**
	Sig. (2-tailed)	<.001		<.001	<.001	<.001
	N	150	150	150	150	150
Blending Method	Pearson Correlation	.558**	.646**	1	.683**	.567**
	Sig. (2-tailed)	<.001	<.001		<.001	<.001
	N	150	150	150	150	150
Blending Temperature	Pearson Correlation	.546**	.643**	.683**	1	.583**
	Sig. (2-tailed)	<.001	<.001	<.001		<.001

	N	150	150	150	150	150
Asphalt Performance	Pearson Correlation	.517**	.581**	.567**	.583**	1
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	
	N	150	150	150	150	150
**. Correlation is significant at the 0.01 level (2-tailed).						

ariables about plastic-modified asphalt are analyzed for correlation and the relationships between plastic type, plastic content, blending method, blending temperature, and performance are of great value for the correlations of the variables. In the table 2, correlation between plastic type and plastic content (r = 0.593) is moderately positive implying that the plastic used affects the amount of plastic associated with the asphalt mixture. Furthermore, plastic-type is positively associated with the blending method (r = 0.558) and the blending temperature (r = 0.546), implying that different plastic types may require different methods or temperatures when being blended with asphalt. Plastic types are emphasized in these correlations in terms of determining
mixing conditions for achieving desired asphalt performance. The correlations obtained between the plastic content variable and the blending method (r = 0.646) and the blending temperature (r = 0.643), suggest that the amount of plastic used depends on the method and the temperature that is required to obtain the best performance. It is also important to note that plastic content also has a moderate positive correlation with asphalt performance (r = 0.581) that higher plastic content contributes to improving the performance of the modified asphalt, particularly in resistance to rutting and durability. The greatest observed correlation was between the blending method and blending temperature (r = 0.683), indicating that the plastic incorporation method and the temperature where sufficient mixing is achieved are strongly interdependent. This correlation implies that the blending temperature has to be well controlled by the method of blending chosen to achieve optimal performance.

Asphalt performance also has moderate to strong positive correlations with all other variables, blending temperature has the largest correlation (r = 0.583). It is consistent with the idea that plastic type, content and mixing conditions greatly affect the performance of plastic modified asphalt. Correlations indicate overall that the selection of plastic-type, content, and blending conditions are important for the attainment of optimum asphalt performance.

Table 3: Regression Analysis:

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.	.669a	.447	.432	.546831980615
b. Predictors: (Constant), Blending Temperature, Plastic Type, Plastic Content, Blending Method				

In the table 3, R^2 value of 0.447 in the Model Summary states that the regression model explains 44.7% of the variance in asphalt performance. The R-value of 0.669 implies that the predictive information for asphalt properties is moderately correlated using the blending temperature, plastic type, plastic content, and bending method as the predictors. When the number of predictors in the model is adjusted, the Adjusted R Square value of 0.432 indicates that after adjusting, the variance in asphalt pavement can be explained by approximately 43.2%. The Standard Error of the Estimate (0.5468) shows the average predicted error and indicates a moderate level of prediction accuracy. While other factors may also play a role, these results indicate that the model is capable of explaining asphalt performance.

Table 4: ANOVA data

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35.096	4	8.774	29.342	<.001b
	Residual	43.359	145	.299		
	Total	78.455	149			
a. Dependent Variable: Asphalt Performance						
b. Predictors: (Constant), Blending Temperature, Plastic Type, Plastic Content, Blending Method						

The ANOVA (Analysis of Variance) table 4, evaluates the overall significance of the regression model that indicates whether the predictors when combined, collectively explain a statistically significant portion of the asphalt performance's variance. That is, we have 35.096 units of Variability explained by the predictors (blending temperature, plastic-type, plastic content, and blending method) in the Sum of Squares for Regression. As a result, this is divided by degrees of freedom (df = 4) associated with the predictors to obtain a Mean Square for Regression of 8.774.

The model explains that the variability in asphalt performance is 43.359, indicating the remaining variability in the asphalt performance. Having 145 degrees of freedom for the residuals, the Mean Square for Residuals is equal to 0.299, which is the average unexplained variance in asphalt performance. A measure of how well the predictors account for the variance of asphalt performance over the residual variance is the F statistic of the model, which is 29.342. The higher the F value is, the better the fit of the model for the data. As shown, the F-statistic Sig. Value for the compound is low (<0.001) and this indicates that the predictors model (blending temperature, plastic type, plastic content, and blending method) statistically can significantly affect asphalt performance.

Table 5: Coefficient factors

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.734	.275		2.667	.009
	Plastic Type	.166	.084	.160	1.976	.050
	Plastic Content	.231	.095	.222	2.446	.016
	Blending Method	.166	.088	.174	1.883	.062
	Blending Temperature	.236	.092	.234	2.547	.012
a. Dependent Variable: Asphalt Performance						

The relationships between independent variables (plastic-type, plastic content, blending method, and blending temperature) and asphalt performance are given in the Coefficients table 5. The unstandardized coefficients (B) are the change in asphalt performance per one unit change in each predictor, for each predictor, with the other variables held constant. For instance, one unit of plastic addition produces an increase of 0.231 in asphalt performance. Like this, the coefficient in the case of blending temperature is 0.236, which implies that the higher the temperature, the better the performance.

The standardized coefficients (Beta) help to show the magnitude of each predictor's contribution to asphalt performance. The plastic content (Beta = 0.222) and blending temperature (Beta = 0.234) have the largest standardized coefficients and hence are the strongest influences on asphalt performance. The p values inform us how possible it is that each predictor is associated. It was found that plastic content (p = 0.016), blending temperature (p = 0.012), and plastic-type (p = 0.050) are statistically significant at the 0.05 level, with the plastic type being marginally significant. The blending method (p = 0.062) is not statistically significant at the 0.05 level but approaches the 0.05 level and may have an influence on asphalt performance.

5. DISCUSSION

With research around to innovate, ways of recycling plastic waste are the rising global concerns of plastic waste and its harm to the environment. The reuse of plastic in road construction using an asphalt mixture as a solution to both the technical and environmental road materials challenges is a promising approach. This study aimed to analyze the effect of recycled plastic on high-temperature performance, low-temperature flexibility, environmental sustainability and cost effectiveness of asphalt mixtures. Taken together, each of these factors is important for deciding the feasibility and overall benefit of using plastic modified asphalt in infrastructure development today.

It is a critical property of asphalt high temperature performance, the ability to resist rutting and deformation under heavy traffic. By studies, it has been demonstrated that recycled plastics, particularly polyethylene (PE) and polypropylene (PP) improve asphalt stiffness and stability at elevated temperatures (Li et al., 2024; Ullah et al., 2024). These plastics increase the rutting resistance of the asphalt by increasing the total viscosity of the binder and hence, reduce the chances of deformation under heavy traffic load. This is particularly useful places where the weather or raid of vehicles is very cordial. This study's findings support these results as a large percentage of the respondents (40.3) agreed that the type of plastic used in asphalt mixtures significantly enhances high temperature performance, especially HDPE and PET, which are known to have higher melting points and work well with asphalt (Mohammed et al., 2024). Selection of an appropriate type of plastic can further optimize the high temperature performance of asphalt. Its relatively higher crystallinity and stiffness makes HDPE superior plastic than more flexible ones LDPE (Yang et al., 2024). In the literature, however, plastic with higher stiffness also increased flexibility might pose a low temperature flexibility problem explored below. As a result, it is essential to be able to blend different types of plastics well with asphalt for a balance between high temperature stability and other required asphalt properties.

Although plastic improved performance at high temperatures, low temperature flexibility and cracking resistance are concerns. Added plastics (such as PET) increase in stiffness, making the asphalt less flexible at low temperatures and increasing the risk of cracking (Shah, 2024). Key to the use of recycled plastics in asphalt is a trade-off with this high temperature stability and low temperature flexibility. At 40.3%, a substantial number (31.3%) agreed that plastic contains low content in the low temperature and another number (31.3%) agreed that the plastic modified asphalt is less cracked in the low temperature. Such results are consistent with previous studies that have showed difficulty in ensuring that the plastic modified asphalt is flexible enough at low temperature, especially under colder climatic conditions (Mehta et al., 2024). As PP and PS in the mix are of high crystallinity, this can worsen the issue as they have limited ability of temperature induced stresses absorption (Xu et al., 2021). It is then from the research point of view one of the key questions with a strong balance between the plastic content giving the high temperature performance and making it flexible enough to not crack in colder climates. Further optimization of the use of plastics and their mixture proportions can mitigate the low temperature performance issues. It is therefore important to investigate the way in which these plastics can be better blended into the asphalt matrix in order to improve high and low temperature performance.

There is little doubt that the use of asphalt containing recycled plastics is a very green product. As regards the huge global plastic waste crisis, there has been a call for more efficient recycling practices and recycling plastics in the road construction reduces the possibility of plastic waste piled into landfills and pollution (Hao el al, 2024). The literature shows use of waste plastics in asphalt to reduce landfill waste and reduce carbon footprint of road construction (Li et al., 2024). Recycled plastics in asphalt have low emissions of carbon dioxide, making it especially environmentally sustainable. According to Benmamoun et al. (2024) and Xu et al. (2021), the use of recycled plastics in asphalt not only aids in reducing the amount of plastic waste present, but it also results in CO2 emissions less than the normal asphalt production methods. In the final stage, plastic modification in asphalt decreases the energy use of its production, therefore reducing the global environmental impact (García et al., 2021). The respondents in this study agreed that plastic modified asphalt is more sustainable than conventional asphalt, 40.5% agreed and 23.0% strongly agreed, because of the relative properties of plastic modified asphalt concerning waste reduction. Furthermore, it reduces the carbon footprint of construction of roads with recycled plastics. Besides this supportive inspiration for the exclusive viable infrastructural development using plastic modified asphalt, there is indeed a possibility of plastic mixed in asphalt to turn the energy intensity of the production of asphalt (Rahman et al., 2020).

Another important issue in relation to the adoption of plastic modified asphalt is its cost effectiveness. Though you may initially pay more in comparison to regular asphalt since the specialized equipment and processing involved in plastic modified asphalt, it will actually come handy in the end as the maintenance and the repairs cost would be less (Singh & Gupta, 2024). Recycled plastic in asphalt provides asphalt that has durability and resistance to rutting and deformation and thus reduced maintenance costs over time. The reduction in the frequency of repairs, especially in the high traffic, high temperature environments, can compensate for the initial costs related to incorporating plastic (Alber et al., 2020). The agreement percentage of respondents in the current study with a result of 37.3 percent agreeing that plastic modified asphalt reduces maintenance needs in the long term supports previous research reporting the economic benefits to the reduced repair and maintenance costs favoring plastic modified asphalt. Economic savings due to the use of recycled plastic are also due to less plastic waste being directed as a landfill, advantageous for the economic sustainability of this solution (Shah, 2024).

6. CONCLUSION

In this study, the possibility of including recycled plastics in the mixes of asphalt for reducing the issues of plastic waste and to do so in an environment friendly way has been explored as research. With plastic waste crisis spreading globally, recycling and repurposing material for plastic is becoming more and more vital to pursue. Roads made from recycled plastics are one such method, which is a dual solution as it is one that reduces the impact on the environment while we have better road materials. The objective of this study was to comprehend the use of recycled plastic as an additive to such asphalt mixture in improving the high temperature performance, low temperature flexibility, environmental merits and cost effectiveness. This study proves the possible benefits and drawbacks of plastic modified asphalt used for road construction. The research aims at the evaluation effect of different types of recycled plastic on asphalt performance in the aspect of high temperature stability, low temperature flexibility, environment sustainability and economization.

The study shows that the type of plastic used in producing the asphalt is critical to its high temperature behavior. On that basis, the authors explain that Polyethylene (PE) and Polypropylene (PP), being known good high temperature asphalt high temperature promoters, have shown superior rutting resistance under the heavy traffic condition. This is also consistent with the previous studies have shown that these plastics can improve the asphalt performance under high temperature condition (Li et al., 2024; Ullah et al., 2024). Further supporting this hypothesis are the survey findings, particularly when it is found that 40.3 percent of the respondents agree that such plastic types as HDPE and PET (high MT and good compatibility with asphalt) significantly improve the life of asphalt at elevated temperatures. According to the study, although recycled plastic allows for increased high temperature performance, it caused some concern over low temperature flexibility and cracking resistance. Plastics such as PET and PP can increase asphalt's stiffness, which in turn reduces its ability to stay flexible at lower temperatures and increases the risk of cracking (Shah, 2024). A critical challenge to the successful use of plastic modified asphalt is the high-temperature stability of the binder versus the low-temperature flexibility of the binder. The results of this study supported the idea that plastics provide higher stiffness to the asphalt, which might limit the asphalt's capacity to withstand temperature induced stresses, and that a higher plastic content decreased low temperature flexibility (agreed by 40.3% of the respondents). Faced with this issue, the plastic content and type used in the mixtures and the development of new plastic blends that are able to maintain high temperature performance and flexibility at low temperature must be optimized.

It was found that there were large environmental benefits of using recycled plastics in asphalt. This method takes the advantage of incorporating waste plastics into road construction, serving as a way to discard it, which normally would be landfilled or incinerated. This study shows that 40.5 % of respondents agreed that plastic modified asphalt is more environmentally friendly than traditional asphalt because the latter has the waste reducing properties. Plastic modified asphalt additionally enhances its environmental sustainability by its potential to decrease the carbon footprint of the asphalt production. Recycled plastic can lower the need for raw materials and CO2 emissions during the asphalt production process, as seen in other recycled material studies (García et al., 2021; Xu et al., 2021). Recycling plastic waste will help reduce the growing global plastic waste problem and increase sustainability in infrastructure construction by road construction industry. Another important discovery of the study is that it cost more initially to blend plastic into asphalt than to traditional asphalt, but recycling plastic into asphalt is more cost effective in the end. Plastic modified asphalt provides durability and are resistant to rutting and deformation and can reduce maintenance and repair costs through time. Additionally, the inclusion of recycled plastics in asphalt decreases overall road construction cost as it does away with the need for other conventional asphalt components. Long-term economic benefits of using recycled materials are seen in the survey results in which 37.3 percent of respondents agree that plastic modified asphalt decreases the need for maintenance over time. Furthermore, the use of recycled plastics in asphalt would also help to reduce costs associated with waste management by reducing amount of plastic waste being sent to landfills, unlike the conventional methods of asphalt production.

Importance of this study is very well seen in the future of road construction and utilizing recycled materials. In addition to being sustainable, the use of plastic modified asphalt represents an alternative to conventional asphalt, capable of reducing plastic waste, carbon emissions and maintenance costs and in the improvement of the overall performance of road surfaces. The results indicate that asphalt plastic modification is most beneficial for asphalt with high temperature performance in regions with high temperatures and heavy traffic. However, issues regarding low temperature flexibility and long-term durability need to be addressed for wider deployment in different regions. To enhance the chances of recycling plastics into asphalt mixtures, it is important to choose the most appropriate and least damaging recycled plastic products. The desired performance would also require the blending method and the mixing temperature to be optimized. This study ascribes wet as the best method, compared with dry, of blending to produce a more uniform mixture, which elucidates the fact that selecting the ideal method of mixing for efficient plastic incorporation is crucial. They contend that more research is needed on new plastic blends, new mixing methods, and new additives that may or may not improve both high-temperature and low-temperature performance, while in a sustainable material.

In discussing the findings of this study on the benefits of plastic modified asphalt, it is important to note that there are several things to be further explored. Optimizing of plastic content and blending techniques would be able to solve the problems of low temperature flexibility and long-term durability with future research. Investigation of compatibility among different types of plastic and their influence on all the performance of asphalt are crucial to develop a best mixture, which can achieve moderating high and low temperature performance. In addition, lifecycle assessment of plastic modified asphalt based on energy consumption, CO2 emission, long-term maintenance cost would contribute to a better understanding of its environmental and economical soundness. New opportunities for asphalt mixtures sustainability might be through using alternative plastics, for example, biodegradable plastics, or mixed plastic waste. Pilot projects and real-world case studies are also important to validate the findings of laboratory experiments, calculate the performance of plastic modified asphalt in various environmental and traffic conditions.

The results of this study indicate that environmentally friendly, economically viable, and performance benefits are possible using recycled plastics in asphalt mixtures. The plastic modified asphalt is a sustainable alternative to conventional asphalt since it decreases plastic waste and improves the performance of road surfaces. The result lines are directed to support the expanding interest in sustainable construction approaches and the part of secondary materials in protracted traffic basic sustenance. Challenges to low temperature flexibility and long-term durability exist; however, continued research and optimization of blending methods, plastic quantity and type will overcome these barriers and allow for widespread use of plastic modified asphalt in most road construction projects in the world. Ultimately, if used and implemented successfully, plastic modified asphalt will go to aid a more sustainable and resilient future for global infrastructure.

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