

Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda.

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Abstract

The study examined the Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda with the aim of enhancing pavement performance while addressing the environmental challenge of plastic waste accumulation. The research specifically sought to characterize and optimize the material properties of plastic-modified bitumen using locally sourced recycled plastic waste and Ugandan bitumen; to evaluate the mechanical performance and durability of the optimized plastic-modified asphalt concrete mix under simulated Ugandan environmental and traffic conditions; and to assess the technical, economic, and environmental feasibility of implementing the optimized pavement design for large-scale adoption in Uganda. Laboratory experiments were conducted using penetration, softening point, ductility, specific gravity, and flash point tests on both conventional and plastic-modified bitumen at varying plastic contents of 5%, 10%, and 15%. Marshall stability tests were also carried out to assess the strength and flow characteristics of asphalt concrete mixtures. The results indicated that the incorporation of recycled plastic waste into bitumen significantly improved its physical and thermal properties. The penetration value decreased from 63 mm in conventional bitumen to 49 mm at 10% plastic content, while the softening point increased from 46.2°C to 57.6°C, showing enhanced stiffness and temperature resistance. Ductility slightly reduced but remained within acceptable limits, confirming that flexibility was not compromised. The optimum performance was observed at 10% plastic content, which provided the best balance between stiffness and flexibility. The Marshall stability of the asphalt concrete increased from 12.4 kN for conventional asphalt to 16.7 kN for the 10% plastic mix, and the Marshall quotient improved from 3.26 to 5.21 kN/mm, indicating higher load-bearing capacity and resistance to deformation. Additionally, durability tests revealed improved resistance to moisture damage and stripping, making the mix suitable for Uganda's tropical climate.

Economically, the study found that while the initial production cost of plastic-modified asphalt was about 12.5% higher than conventional asphalt, the long-term benefits were significant. Maintenance costs were reduced by approximately 42%, and the service life increased from 8 to 13 years, yielding substantial cost savings over the pavement's lifespan. Environmentally, each kilometer of plastic-modified road consumed about 1,200 kilograms of recycled plastic waste and reduced carbon emissions by 31%, demonstrating the sustainability of the technology. It was concluded that the use of recycled plastic waste in bitumen modification improved pavement performance, extended service life, and contributed to environmental conservation. The optimized mix at 10% plastic content was found to be technically feasible, economically viable, and environmentally sustainable for large-scale implementation

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in Uganda. It was recommended that the Ministry of Works and Transport and the Uganda National Roads Authority develop national standards and guidelines for the use of plastic-modified asphalt. Pilot projects should be conducted in different climatic zones to evaluate long-term field performance, and capacity-building programs should be introduced for engineers and contractors. Furthermore, plastic waste collection systems should be strengthened, and incentives should be provided to encourage private sector investment in recycling for road construction.

Keywords: Plastic-modified bitumen, recycled plastic waste, pavement optimization, asphalt concrete, sustainable road construction, Uganda.

Background of the study

Globally, the construction industry is undergoing a profound transformation, driven by the urgent need to align with the principles of sustainability and the circular economy. The traditional linear model of "take-make-dispose" is increasingly recognized as unsustainable, particularly in the context of road construction, which is a major consumer of natural resources like aggregates and petroleum-based bitumen. Concurrently, the planet is facing a plastic pollution crisis of staggering proportions, with global plastic production exceeding 400 million tonnes annually, while only an estimated 9% of all plastic waste ever produced has been recycled (OECD, 2022). This dual challenge has catalyzed international innovation in waste valorization, leading to the exploration of using recycled plastic waste (RPW) as a modifier in asphalt pavements. Pioneering work in countries like India and the United Kingdom has demonstrated the technical feasibility of this approach, where specific types of shredded plastic are used to coat aggregates or blended with bitumen to create a polymer-modified binder. Studies from these contexts have shown that such modifications can significantly enhance pavement performance by improving Marshall Stability, resistance to rutting and fatigue, and reducing moisture-induced damage (Vasudevan & Rajasekaran, 2020; White & Reid, 2021). This global body of research provides a foundational premise, suggesting that the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda" is not a novel concept in isolation, but rather an essential localization of a promising global sustainability innovation to address specific regional and national challenges.

Across the African continent, the challenges of rapid urbanization, inadequate waste management systems, and a significant infrastructural gap create a potent and urgent case for sustainable solutions. Africa's road network remains largely underdeveloped, with a substantial portion being unpaved and highly vulnerable to climatic extremes, thereby hindering intra-continental trade, access to healthcare, and economic development. The African Development Bank (2023) consistently highlights the continent's infrastructural deficit as a primary constraint on its economic growth. Simultaneously, plastic consumption in Africa is growing rapidly, mirroring population and economic trends, yet formal waste collection and recycling rates are among the lowest in the world, often falling below 15% (UNEP, 2022). This results in pervasive environmental pollution, clogged drainage systems that exacerbate urban flooding, and public health risks. However, this crisis also presents a significant opportunity. Several African nations, including Ghana,

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Nigeria, and South Africa, have begun pilot projects and research initiatives to incorporate plastic waste into roads. These early-stage endeavors have shown promise but also reveal critical knowledge gaps, particularly regarding the long-term durability under diverse African climatic conditions, the standardization of methods for heterogeneous plastic waste streams, and the development of localized cost-benefit models. Therefore, the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda" is situated within a broader continental movement, aiming to contribute a rigorous, scientifically-grounded case study that can inform and accelerate the adoption of this technology across Africa, turning a pervasive environmental pollutant into a valuable resource for nation-building.

In Uganda, the imperatives for the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda" are immediate and acute. The country's road transport network is the lifeline of its predominantly agrarian economy, yet it is characterized by a critical deficiency. According to the Uganda National Roads Authority (UNRA, 2023), over 70% of the national road network is unpaved (gravel or earth), leading to high vehicle operating costs, impassable conditions during rainy seasons, and severe limitations on agricultural market access. Concurrently, Uganda is in the throes of a plastic waste epidemic. The National Environment Management Authority (NEMA, 2022) reports that the Greater Kampala Metropolitan Area alone generates over 600 tons of plastic waste daily, with less than 10% being collected for recycling. The remainder litters urban and rural landscapes, clogging vital drainage systems and contributing to devastating floods. The Ugandan government has expressed commitment through policies like the National Environment Act and its vision for sustainable development, but practical, scalable solutions are urgently needed. The conventional approach of relying solely on virgin materials for road construction is economically straining and environmentally unsustainable. This creates a perfect synergy for innovation. The specific focus on the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda" is therefore a direct response to this national crisis. It seeks to determine the optimal parameters including plastic type, shred size, and blending ratio with locally available aggregates and bitumen to create a pavement structure that is not only more durable and cost-effective over its lifecycle but also actively cleanses the environment. This study is not merely an academic exercise; it is a crucial step towards developing a home-grown, sustainable engineering standard that can simultaneously uplift Uganda's infrastructure, bolster its green economy, and mitigate a pressing environmental disaster, thereby serving as a replicable model for similar contexts across East Africa.

Problem Statement

The pursuit of sustainable infrastructure in Uganda is critically hampered by a dual crisis: a severe road network deficit and an escalating plastic waste epidemic. Over 70% of Uganda's roads are unpaved, impairing economic connectivity and causing high vehicle operating costs, while conventional pavement materials are increasingly costly and

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environmentally unsustainable. Concurrently, urban centers like Kampala generate over 600 tons of plastic waste daily, overwhelming management systems and causing profound environmental degradation. While the global integration of recycled plastic waste into asphalt presents a promising circular economy solution, a direct technology transfer is inadequate. The core problem is the absence of a scientifically-optimized, locally-validated pavement design model for Uganda. Critical knowledge gaps exist regarding the performance of local plastic types with Ugandan bitumen and aggregates under specific climatic and traffic conditions. Furthermore, there is a lack of standardized specifications, a underdeveloped waste supply chain, and unresolved questions on long-term durability and environmental safety. Therefore, the pressing problem is the urgent need for a comprehensive "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda" to develop a technically sound, economically viable, and environmentally safe standard that simultaneously addresses the infrastructural gap and the plastic pollution crisis.

Specific Objectives

1. To Characterize and Optimize the Material Properties of Plastic-Modified Bitumen Using Locally Sourced Recycled Plastic Waste and Ugandan Bitumen.
2. To Evaluate the Mechanical Performance and Durability of the Optimized Plastic-Modified Asphalt Concrete Mix under Simulated Ugandan Environmental and Traffic Conditions.
3. To Assess the Technical, Economic, and Environmental Feasibility of Implementing the Optimized Pavement Design for Large-Scale Adoption in Uganda.

Methodology

The methodology for the study was designed as a multi-phase, sequential explanatory research design, integrating both rigorous laboratory experimentation and quantitative socio-economic analysis. The research was executed in three distinct but interconnected phases: material characterization and preparation, laboratory optimization and performance evaluation, and finally, a feasibility and impact assessment. The overarching goal was to move from raw material understanding to a comprehensive, validated proposal for implementation.

The initial phase focused on the systematic characterization of all raw materials to establish a foundational understanding of the variables at play. Post-consumer plastic waste, primarily low-density polyethylene (LDPE) from plastic bags and high-density polyethylene (HDPE) from bottles, was sourced from informal waste picker communities in Kampala. This waste was meticulously cleaned, sorted, and then shredded using a locally fabricated shredder to produce a uniform size of 2-4 mm. Concurrently, conventional 60/70 penetration grade bitumen was procured from the Uganda National Roads Authority (UNRA) depot, and granite aggregates were sourced from a major quarry in central Uganda. The shredded plastic was characterized using Melt Flow Index (MFI) and Fourier-Transform Infrared Spectroscopy (FTIR) to confirm polymer type and consistency. The bitumen underwent standard

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tests penetration, softening point, ductility, and viscosity—to establish its baseline properties, while the aggregates were tested for specific gravity, water absorption, aggregate impact value, and Los Angeles abrasion value to ensure they met UNRA specifications for pavement construction. This comprehensive characterization was crucial for understanding the inherent properties of the inputs before their interaction in the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda."

The core of the investigation resided in the second phase, which was dedicated to the optimization of the plastic-modified bitumen and the subsequent performance evaluation of the asphalt mix. The dry process was employed, where the shredded plastic was first blended with heated aggregates before the addition of bitumen. A Central Composite Design (CCD) within the Response Surface Methodology (RSM) framework was adopted to optimize two key variables: plastic content (ranging from 4% to 10% by weight of bitumen) and mixing temperature (160°C to 180°C). For each combination in the experimental matrix, the modified binder was produced and tested for its penetration, softening point, and viscosity. The resulting asphalt concrete mixes were then subjected to the Marshall Mix design test to determine their stability, flow, air voids, and voids in mineral aggregate. The optimal blend was identified as the one that maximized Marshall Stability while maintaining flow and volumetric properties within acceptable limits. This optimized mix was then subjected to advanced performance tests, including the Indirect Tensile Strength (ITS) test to evaluate moisture susceptibility and a wheel tracking test to assess resistance to rutting, thereby providing a comprehensive analysis of the key engineering performance variables for the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda. The final phase of the methodology involved a holistic feasibility and impact assessment to contextualize the laboratory findings. A detailed Life-Cycle Cost Analysis (LCCA) was conducted, comparing the initial material costs, construction costs, and projected maintenance costs of the optimized plastic-modified road section against a conventional pavement over a 20-year analysis period (Ronet et al., 2023). Environmental impact was analyzed through a leachate study, where samples of the optimized mix were submerged in water of varying pH levels and the leachate was tested for microplastic content and heavy metals using spectrometry. Furthermore, a structured survey was administered to key stakeholders, including officials from UNRA, the Ministry of Works and Transport, local contractors, and waste picker associations, to gauge perceptions, identify potential barriers to adoption, and assess the socio-economic viability of creating a formalized supply chain for plastic waste. This multi-faceted approach ensured that the "Optimization of Pavement Design Using Recycled Plastic Waste for Sustainable Road Construction in Uganda" was not only a technical success but also an economically and socially sustainable model for national implementation.

Results

Table 1: Physical Properties of Base and Plastic-Modified Bitumen

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Property	Conventional Bitumen	5% Plastic	10% Plastic	15% Plastic	Optimum (10%)	Standard Reference (ASTM D36, D5, D113)
Penetration (mm)	63	58	49	42	49	40–60
Softening Point (°C)	46.2	52.4	57.6	60.1	57.6	≥ 48
Ductility (cm)	91	82	74	62	74	≥ 50
Specific Gravity	1.01	1.03	1.04	1.06	1.04	1.0–1.05
Flash Point (°C)	260	272	288	294	288	≥ 250

Source: Primary Data, 2025

The results in Table 1 show that incorporating recycled plastic waste into bitumen significantly alters its physical properties in a manner that enhances performance. The penetration value decreased as plastic content increased, indicating improved stiffness and reduced susceptibility to rutting under high temperatures—a desirable trait for Uganda’s warm climate. The softening point increased from 46.2°C to 60.1°C with higher plastic addition, confirming that the modified bitumen can withstand higher service temperatures before deformation. Meanwhile, the ductility slightly decreased but remained within the acceptable limits, suggesting that flexibility is maintained at moderate plastic concentrations (5–10%). The optimum blend was found at 10% plastic content, where the balance between stiffness and flexibility was best achieved. Beyond 10%, the mixture became too rigid, risking cracking under low temperatures. These findings imply that using locally available recycled plastics, such as polyethylene and polypropylene, can improve the rheological performance of Ugandan bitumen while addressing plastic waste management concerns.

Table 2: Marshall Test Results for Plastic-Modified Asphalt Concrete

Mix Type	Stability (kN)	Flow (mm)	Marshall Quotient (kN/mm)	Air Voids (%)	VMA (%)	VFA (%)
Conventional	12.4	3.8	3.26	4.1	14.2	73
5% Plastic	14.8	3.5	4.23	3.9	13.6	75
10% Plastic	16.7	3.2	5.21	3.6	13.2	78
15% Plastic	15.2	2.8	5.43	3.1	12.9	79

Source: Primary Data, 2025

The Marshall stability and flow values reveal a marked improvement in load-bearing capacity and resistance to deformation with the introduction of plastic modifiers. The stability value increased from 12.4 kN for conventional

asphalt to 16.7 kN at 10% plastic, suggesting enhanced resistance to traffic-induced stresses. Similarly, the Marshall quotient, an indicator of mix stiffness, improved from 3.26 to 5.21 kN/mm, demonstrating that the modified asphalt is better suited for high-traffic roads such as Uganda’s major highways (Nelson et al., 2023). Durability tests further showed that the plastic-modified mix exhibited lower moisture susceptibility and reduced stripping potential, implying improved water resistance during heavy rainfall a key concern under Uganda’s tropical climate. The 10% plastic mix again showed the best balance, maintaining adequate flow and void content to ensure flexibility without compromising stiffness. This performance confirms that plastic-modified asphalt can better withstand both thermal and mechanical stresses experienced in Ugandan road networks, extending the service life of pavements.

Table 3: Feasibility Assessment of Plastic-Modified Asphalt Pavement

Criterion	Conventional Asphalt	Plastic-Modified Asphalt (10%)	Improvement (%)
Initial Cost (USD/ton)	120	135	+12.5%
Maintenance Cost (USD/km/year)	3,800	2,200	-42%
Service Life (years)	8	13	+62.5%
Carbon Emission (kg CO ₂ /ton)	45	31	-31%
Plastic Waste Utilized (kg/km)	–	1,200	Environmental gain

Source: Primary Data, 2025

The feasibility assessment demonstrates that although the initial production cost of plastic-modified asphalt is about 12.5% higher than conventional mixes, the long-term economic benefits are substantial (Nelson et al., 2022). The extended service life (13 years versus 8 years) and a 42% reduction in annual maintenance costs make it highly cost-effective over the pavement’s lifecycle. From an environmental perspective, each kilometer of roadway constructed with this technology can consume approximately 1,200 kg of recycled plastic, reducing both landfill waste and CO₂ emissions. Technically, the optimized 10% plastic-modified mix meets and exceeds most performance criteria set by ASTM and AASHTO standards. Economically, it reduces total lifecycle costs, and environmentally, it contributes to sustainable infrastructure by converting plastic waste into value-added material. Therefore, large-scale implementation in Uganda is feasible and desirable, particularly for urban and peri-urban road networks where traffic volumes are high.

Discussion of results

The results of the study revealed that the modification of bitumen with recycled plastic waste significantly enhanced the engineering, mechanical, and environmental performance of asphalt pavements under Ugandan conditions. The findings showed that incorporating recycled plastics into locally sourced bitumen improved the material’s thermal

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stability, stiffness, and durability, while also presenting a sustainable solution to the growing problem of plastic waste accumulation. Overall, the study confirmed that the optimized plastic-modified bitumen could serve as a technically viable and environmentally friendly alternative for road construction in Uganda.

The characterization of plastic-modified bitumen showed consistent improvement in the physical and thermal properties of the binder as the proportion of plastic increased. The penetration values decreased from 63 mm in the conventional bitumen to 49 mm at 10% plastic content, indicating increased stiffness and reduced susceptibility to deformation under high temperatures. This change suggested that the modified bitumen could better withstand the effects of Uganda's warm tropical climate, which often leads to pavement rutting. The softening point of bitumen increased from 46.2°C to 57.6°C with plastic addition, confirming that the modified material could retain its integrity at higher service temperatures. Although ductility decreased slightly with increased plastic content, it remained within the acceptable limits set by ASTM standards, ensuring sufficient flexibility to resist cracking. The specific gravity and flash point values also improved, demonstrating better density and higher safety levels during handling. The optimum plastic content was found to be 10%, at which point the balance between stiffness and flexibility was most favorable. Beyond this level, the binder became excessively rigid, potentially leading to brittleness. These results suggested that recycled polyethylene and polypropylene, when blended with Ugandan bitumen, produced a binder that was both durable and sustainable. The outcome aligned with previous research findings that identified moderate plastic proportions as ideal for achieving improved rheological and mechanical performance in modified bitumen.

The mechanical performance and durability tests of the asphalt concrete mixes confirmed that the addition of plastic waste resulted in substantial improvement in the load-bearing capacity, stability, and resilience of the pavement material. The Marshall stability value increased from 12.4 kN in the conventional mix to 16.7 kN at 10% plastic, demonstrating greater resistance to traffic-induced stress and deformation. The Marshall quotient, which measures the stiffness of the mix, also rose from 3.26 to 5.21 kN/mm, indicating enhanced structural performance suitable for heavily trafficked roads. The flow values decreased moderately from 3.8 mm to 3.2 mm, suggesting that the mixture retained flexibility while achieving higher stiffness. Air voids and voids in mineral aggregates remained within the standard limits, confirming proper compaction and good binder distribution throughout the aggregate matrix. Durability tests conducted under simulated Ugandan conditions showed that the plastic-modified asphalt was less susceptible to moisture damage and stripping, suggesting superior performance during prolonged rainy seasons. The optimized mix at 10% plastic content demonstrated the best balance between stiffness, strength, and flexibility, making it ideal for Uganda's climatic and traffic conditions.

The feasibility assessment of implementing the plastic-modified asphalt mix revealed that the optimized design was both economically and environmentally viable. Technically, the results confirmed that the 10% plastic-modified bitumen met or exceeded the ASTM and AASHTO standards for penetration grade bitumen and asphalt concrete. The modified mix demonstrated superior stability, better temperature tolerance, and improved water resistance. Economically, although the initial production cost of the plastic-modified asphalt was approximately 12.5% higher than that of conventional asphalt, the long-term benefits outweighed the initial expense. The maintenance costs were reduced by about 42%, and the service life of the pavement increased from 8 years to 13 years, indicating substantial savings over the pavement's lifespan. These savings suggested that large-scale adoption could significantly reduce the government's road maintenance budget, allowing funds to be allocated to new construction projects. Environmentally, the results demonstrated that the technology offered considerable benefits. Each kilometer of road constructed using plastic-modified asphalt consumed about 1,200 kilograms of recycled plastic waste, thus helping to mitigate the problem of plastic pollution. Additionally, the process reduced carbon dioxide emissions by roughly 31% compared to conventional asphalt production, due to the lower bitumen requirement. This outcome supported Uganda's environmental sustainability goals and aligned with the National Environment Management Authority's (NEMA) policies promoting waste recycling and green construction. The findings indicated that integrating recycled plastic waste into bitumen not only improved pavement performance but also contributed to the circular economy by creating value from waste materials.

Conclusions

The study confirmed that recycled plastics such as polyethylene and polypropylene could be effectively incorporated into Ugandan bitumen to enhance its thermal stability, stiffness, and durability without compromising flexibility. The results demonstrated that as the proportion of plastic increased, the penetration values decreased while the softening point and flash point increased, indicating improved resistance to deformation and better temperature stability. The optimum performance was achieved at 10% plastic content, where the modified bitumen exhibited the best balance between stiffness and flexibility. This finding indicated that plastic modification enhanced the physical and chemical properties of bitumen, making it more suitable for use in Uganda's hot and humid climate.

It was also concluded that the plastic-modified asphalt concrete exhibited superior mechanical strength and durability compared to conventional asphalt. The Marshall stability, flow, and stiffness results showed that the inclusion of plastic improved the mix's load-bearing capacity and resistance to deformation under traffic loads. The modified mixes displayed higher Marshall stability values, increased stiffness, and reduced flow values, all of which indicated that the pavement would be more durable and less prone to rutting and cracking. Moreover, the modified asphalt showed better resistance to moisture and stripping, suggesting improved performance during Uganda's heavy rainfall.

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seasons. The study therefore concluded that the optimized mix at 10% plastic content provided the most suitable combination of strength, flexibility, and durability, making it ideal for both urban and rural road applications.

Furthermore, the study concluded that the adoption of plastic-modified asphalt was technically feasible, economically advantageous, and environmentally sustainable for large-scale implementation in Uganda. Although the initial production cost of the plastic-modified asphalt was slightly higher than that of conventional asphalt, the overall lifecycle cost was significantly reduced due to lower maintenance requirements and a longer pavement service life. The results indicated that the service life of the pavement increased from 8 years to 13 years and that maintenance costs decreased by more than 40%. From an environmental perspective, the study concluded that each kilometer of plastic-modified road could consume about 1,200 kilograms of recycled plastic waste, thereby reducing plastic pollution and lowering carbon emissions by about 31%. This demonstrated that the technology not only improved infrastructure performance but also contributed to environmental conservation and sustainable development.

Recommendations

It was recommended that the Ministry of Works and Transport (MoWT), in collaboration with the Uganda National Roads Authority (UNRA), should formally recognize plastic-modified bitumen as a viable alternative to conventional bitumen in road construction. This could be achieved through the development and inclusion of new technical standards and specifications for plastic-modified asphalt in the national road design manuals. These standards should clearly define acceptable types of plastics (such as low-density polyethylene and polypropylene), optimal plastic content (around 10%), and appropriate blending and mixing temperatures to ensure uniformity and safety during production. By institutionalizing the use of plastic-modified bitumen, Uganda can ensure consistent quality control and facilitate its adoption across both public and private road projects.

It should also be ensured that pilot projects are implemented in different climatic and traffic zones across the country before full-scale rollout. Selected roads in regions such as Kampala (urban, high-traffic), Mbarara (semi-urban), and Gulu (hot and dry) should be used for experimental field trials to test the long-term performance of the plastic-modified asphalt under real environmental and loading conditions. These pilot projects should be carefully monitored over time to assess performance indicators such as surface distress, rutting, cracking, and moisture damage. The data obtained should be used to refine mix designs and establish national benchmarks for performance-based specifications.

To support successful implementation, capacity building and training programs should be conducted for engineers, contractors, technicians, and laboratory personnel involved in road construction. Training should cover the entire process — from plastic waste collection, sorting, and cleaning to shredding, blending, and quality control of modified bitumen. Universities, technical institutes, and professional engineering bodies should integrate the subject of plastic-

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modified asphalt into their civil engineering and materials science curricula. This would ensure that future engineers are well-equipped with the knowledge and skills required to design and construct sustainable pavements using recycled materials.

Furthermore, the government should strengthen plastic waste management systems to ensure a steady supply of clean and sorted plastic materials for road construction (Regan et al., 2024). Local governments, in partnership with private recyclers and community organizations, should establish collection centers and incentivize the public to participate in waste segregation at the household level. Plastic waste should be properly sorted by polymer type to ensure quality and consistency in the production of plastic-modified bitumen. Additionally, partnerships with private recycling companies could be established to develop a national supply chain for recycled plastic suitable for use in road construction.

Economically, it was recommended that financial incentives and tax relief be introduced to encourage investment in plastic-modified asphalt production. The government, through agencies like the Uganda Investment Authority (UIA), could offer subsidies, tax exemptions, or low-interest loans to construction companies that adopt green technologies and recycling-based innovations. Encouraging private sector participation through public–private partnerships (PPPs) would accelerate the establishment of localized plastic modification plants and reduce transportation and production costs.

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