© September 2024 | IJIRT | Volume 11 Issue 4 | ISSN: 2349-6002

Eco-Friendly Roads: Combining Recycled Plastic and Pervious Blocks for Environmental Sustainability

Reena P[1], Mohanapriya V[2], Sathiyapriya V[3], Ruthish kumar G[4], Venkatesh R[5]
Assistant Professor/Civil, JKKMCT, T.N Palayam. Erode

ABSTRACT: As global challenges such as plastic pollution and urban storm water management intensify, innovative and sustainable solutions are increasingly vital. This study explores a groundbreaking approach to road construction by integrating recycled plastic and pervious concrete. By embedding recycled plastic waste into asphalt, we address plastic pollution, enhance the longevity of roads, and reduce maintenance expenses. The inclusion of pervious concrete, which allows water to permeate through its surface, effectively reduces urban runoff and supports groundwater recharge. The research aims to assess the structural strength, water permeability, and environmental impact of roads built using plastic-modified asphalt and pervious concrete. Laboratory experiments and field trials will evaluate the performance of these materials under different conditions, including varying traffic loads and rainfall. Additionally, life cycle analyses will be carried out to measure the environmental advantages and potential drawbacks of this innovative construction technique in comparison to traditional methods. The outcomes of this research could transform road infrastructure, offering a sustainable solution to plastic waste and urban water management while enhancing the environmental resilience of cities.

Keywords: Green Building Materials, Recycled Plastic, Pervious Concrete, Storm Water Management and Environmental Resilience.

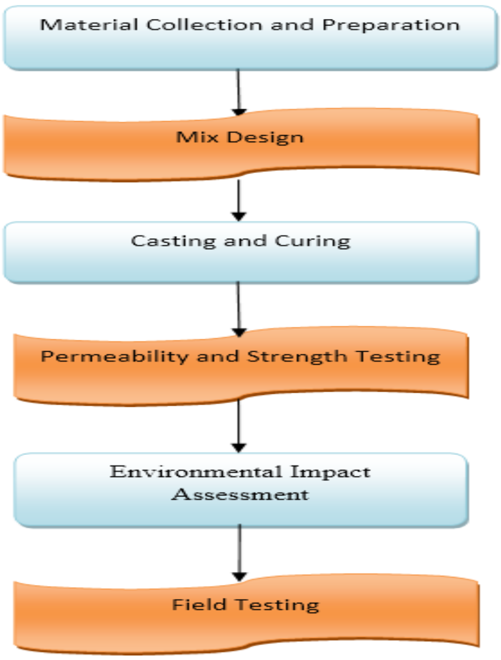
I. INTRODUCTION

As urbanization rapidly accelerates, cities face mounting environmental challenges, including plastic waste accumulation and increased stormwater runoff. Traditional road construction methods, primarily reliant on non-renewable materials like asphalt and concrete, contribute to environmental degradation and resource depletion. Moreover, impermeable surfaces exacerbate urban flooding by preventing natural water infiltration, which stresses drainage systems and reduces groundwater recharge.

In response to these issues, sustainable road construction techniques have gained significant attention in recent years. One promising approach involves the integration of recycled plastic into asphalt and the use of pervious blocks. Recycled plastic-modified asphalt not only diverts plastic waste from landfills and oceans but also enhances the durability and flexibility of roads, potentially lowering long-term maintenance costs. Simultaneously, pervious blocks allow water to pass through the pavement surface, reducing surface runoff, mitigating flood risks, and promoting groundwater replenishment.

By investigating the structural performance, environmental benefits, and economic feasibility of these eco-friendly materials, this research seeks to contribute to a future where infrastructure development aligns with environmental stewardship. Through laboratory tests and field trials, the study aims to demonstrate how this innovative road construction method can address two critical urban challenges: plastic waste management and storm water control.

II.METHODOLOGY



1. Recycled Plastic Aggregates: In this study, recycled plastic sourced from post-consumer waste, uch as polyethylene terephthalate (PET) bottles, is utilized. The plastic waste undergoes a shredding process to obtain fine particles or small aggregates that can be mixed into concrete or used as an additive in asphalt. The recycled plastic helps reduce the demand for virgin materials and diverts waste from landfills.
2. Pervious Concrete Blocks: The pervious blocks used in this research are manufactured using a mix of coarse aggregates, cement, and minimal fine aggregates. These blocks allow for high permeability, enabling water to seep through and reducing surface runoff. Pervious blocks play a crucial role in stormwater management, contributing to environmental sustainability.
3. Binding Agents: For both asphalt and concrete applications, suitable binding agents, such as Portland cement for concrete and bitumen for asphalt, are used. These binding agents ensure the durability and mechanical strength of the resulting materials when combined with recycled plastics.
4. Water: The use of clean water is essential for the mixing process in concrete. Proper water-cement ratios are maintained to achieve optimal curing and strength in the pervious blocks.
5. Additives: In some cases, additional additives such as silica fume or fly ash are included to enhance the strength and durability of the concrete. These materials are also selected for their environmental benefits, as they are often by-products of other industrial processes.

IV.DESIGN MIX PROPORTIONS

The optimal mix design must balance strength, permeability, and the incorporation of recycled plastic.

1. Cement to Plastic Ratio**:** Varies depending on the type of plastic. A range of 5-20% plastic by volume will be tested.
2. Water-Cement Ratio**:** Maintaining a low water-cement ratio is crucial to ensure durability, typically ranging from 0.35-0.45.
3. Aggregates**:** The size and type of aggregates will affect permeability. Coarse aggregates with sizes ranging from 9.5 mm to 20 mm will be selected to ensure water flow and structural strength.
4. Plastic Fiber Inclusion**:** In some cases, shredded plastic fibers will be introduced to enhance tensile strength and crack resistance.

V.TESTING AND EVALUATION

1. Compressive Strength**:** Tests will be conducted at various stages (7, 14, 28 days) to assess strength characteristics of the road material.
2. Permeability**:** The pervious blocks will be evaluated for infiltration rates using standard methods, ensuring adequate water permeability.
3. Durability**:** Freeze-thaw resistance, abrasion, and chemical exposure will be tested to assess the road's long-term performance.

VI.ENVIRONMENTAL IMPACT

This combination aims to reduce the ecological footprint of road construction by:

1. Reducing plastic waste.
2. Enhancing water infiltration to mitigate urban flooding.
3. Lowering carbon emissions through reduced use of virgin materials.

VII. BENEFITS OF SUSTAINABLE ROADS

Sustainable roads, which incorporate innovative materials like recycled plastic and pervious blocks, offer numerous environmental and practical advantages. First, by using recycled plastic, these roads help reduce the accumulation of plastic waste in landfills and oceans, contributing to less environmental pollution. Additionally, such materials can enhance the durability and longevity of the road surfaces, potentially lowering maintenance costs and extending their lifespan.

Pervious blocks, which allow water to pass through, are a significant feature in stormwater management. These blocks help mitigate the risk of flooding by promoting water infiltration and reducing runoff, thereby protecting nearby ecosystems and reducing strain on urban drainage systems. Furthermore, roads designed with sustainability in mind can lower the urban heat island effect, as some materials reflect rather than absorb heat, leading to cooler surrounding areas.

By prioritizing sustainable construction practices, eco-friendly roads also contribute to a decrease in the use of non-renewable resources, which helps conserve natural materials. Ultimately, these roads represent a forward-thinking approach to infrastructure that balances environmental responsibility with economic efficiency.

VIII. PLASTIC ROADS

Procedure: The concept of plastic roads involves utilizing waste plastics, such as plastic bags, and packaging materials, as a component in road construction. Instead of discarding these plastics into landfills or oceans they are repurposed and integrated into the asphalt mixture used for road paving.

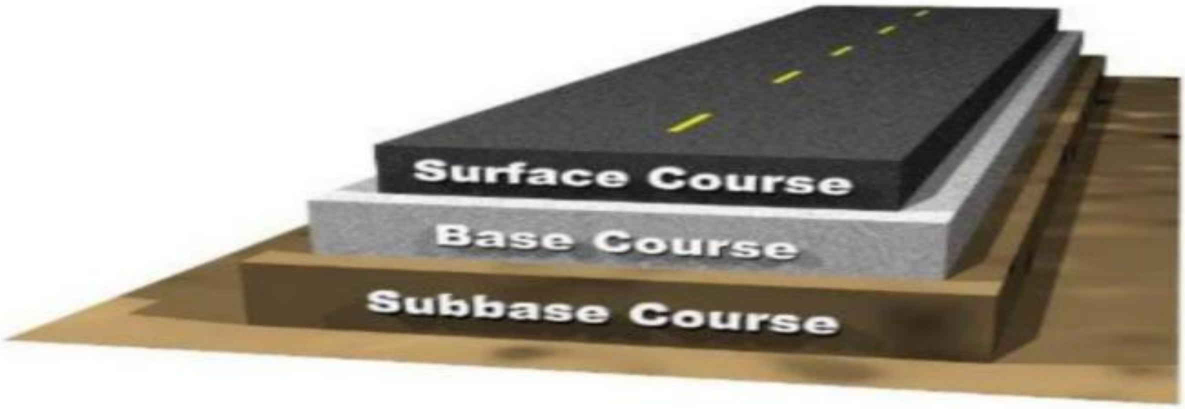


Fig 1- Layer of recycled plastic road

Fig 2- Layer of recycled plastic road subbase course

Fig 3- Layer of recycled plastic road base corse plastic material

Fig 4- Layer of recycled plastic road surface course

Fig 5- Eco-Friendly Roads: Combining Recycled Plastic

IX. PERVIOUS CONCRETE

Pervious concrete is a special high porosity concrete used for flatwork applications that allows water from precipitation and other sources to pass through, thereby reducing the runoff from a site and recharging ground water levels. Its void content ranges from18 to 35% with compressive strengths of (400 to 500 psi).

Fig 6- Eco-Friendly Roads: Combining Recycled Plastic & Pervious Concrete

PERVIOUS BLOCK

Fig 7- Eco-Friendly Roads: Combining Recycled Plastic & Pervious Block

X. COST SAVINGS

1. Sustainable road building practices can result in cost savings for both the government and private sector.
2. By reducing the need for expensive stormwater management systems, sustainable road building practices can lower costs.
3. Additionally, by avoiding legal battles and fines that may arise from environmental degradation, sustainable road building practices reduce financial risks.

CONCLUSION

The integration of recycled plastic into pervious concrete blocks offers a sustainable and eco-friendly alternative for road construction. By using waste plastic materials, this approach not only helps in managing plastic waste but also reduces the environmental impact associated with traditional road materials. Additionally, the pervious nature of these blocks promotes better water management by allowing rainwater to permeate through the surface, thus mitigating flood risks and enhancing groundwater recharge. The combination of these factors contributes to a more sustainable infrastructure system, capable of addressing both environmental and urban challenges. Moving forward, this innovative method has the potential to significantly reduce carbon emissions and resource consumption, promoting long-term environmental sustainability in road construction practices. Further research and development in this area will help optimize the material composition and structural properties of recycled plastic-pervious concrete blocks for broader implementation.

REFERENCES

[1]. M.B.A.A.Ahmed, N.S.A.Zain, M.Z. Mohd Zaki .Recycling of plastic waste as a sustainable building material :A review.. 2020 Volume 258, 120989.

[2]. A.R.A. Santos, J.B.F. Silva, J.E.E.S. Pereira, Utilization of recycled plastic waste in concrete: A review. 2019. Volume 204, Pages 205-214

[3]. S.K.T.D. Agbede, M.A.A.A. Olayanju. Use of recycled plastic in concrete: A comprehensive review, 2019 . Volume 12, Issue 7, 1176.

[4]. J.O.Adetola, C.A.Ogundipe ,Sustainable alternatives for the construction industry: Utilizing recycled plastic in roads, 2021, Volume 280, 111844.

[5]. N.K.Pal, M. K. S. Ali, R.S.D.Raza ,Assessment of the potential of using recycled plastic in road construction**:** 2018.Volume 134, Pages 236-245

[6]. E. M.Di Maria, C.F.C. Castilho, R.M.L. de Oliveira ,Pervious concrete made with recycled plastic aggregates: A sustainable solution for urban drainage**,** 2021,Volume 28, 100858

[7]. L.A.S.L. Benavides, T.M. Morales Life cycle assessment of plastic waste use in road construction, 2020.Volume 106, Pages 144-155

[8]. J.M.M.Mbuthia, L.N. Munyiri ,Green road construction: The role of recycled plastics in sustainable road infrastructure.2021,Volume 28, Pages 17778-17793