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Crumb Rubber used in Pavement Design

Lavanya Santosh Rokade
rokadelavanya94@gmail.com
VES Polytechnic, Mumbai, Maharashtra

Manasi Shubhas Fulare
ce2022.manasi.fulare@ves.ac.in
VES Polytechnic, Mumbai, Maharashtra

Srushti Kishor Salve
ce2022.srushti.salve@ves.ac.in
VES Polytechnic, Mumbai, Maharashtra

Saburi Shashikant Shivan
ce2022.saburi.shigvan@ves.ac.in
VES Polytechnic, Mumbai, Maharashtra

Suraj Surve
ce2022.suraj.surve@ves.ac.in
VES Polytechnic, Mumbai, Maharashtra

ABSTRACT

Pavement design is a critical process in the construction of road infrastructure, aimed at creating durable, cost-effective, and sustainable surfaces that can withstand traffic loads, environmental conditions, and wear over time. The design methodology involves several factors, including traffic load, climate, soil properties, material selection, and the type of pavement (flexible or rigid). Traditional pavement design methods such as empirical approaches (e.g., AASHTO) rely on established guidelines and field data, while more advanced techniques, such as mechanistic-empirical methods, integrate both mechanical analysis and field performance data for a more accurate prediction of pavement behavior.

Keywords— *Industrial Waste, Agricultural Waste, Rubberized Concrete*

INTRODUCTION

Concrete is the building material that is most frequently utilized globally. The contribution of the utilization of concrete in the infrastructure industry is a very significant factor to be considered for nation building, as infrastructural growth [1] is the measure of the development of any country. As almost all the ingredients of concrete are obtained from natural resources, the construction industry is facing a dearth of constituents and a hike in the cost of concrete [2]. Unsustainable mining of sand from rivers has its disadvantages to the environment as aquatic life is disturbed and as this is a natural resource, so obtainable in restricted quantities on our globe. At present-day, every part of the world is facing a scarcity of sand. To control this unmaintainable extraction every nation has its own rules and principles but then again these are not sufficient moves to control sand extraction without compromising the pace of national growth. There is a need to develop an alternate material for sand from numerous wastes generated by human activity. The great escalation in the automobile industry in the last three decades raised the problem of the disposal of discarded/end-of-life tires [3]. Discarded tires cause problems connected to human health, and the environment like land pollution, burning of such tires causes air pollution, etc. [4]. Developing nation-states like India are facing these issues on a very outsized scale. However, as the construction sector expands, there is a corresponding rise in cement demand, which raises CO2 emissions. Replacing the cement with supplementary cementitious material like ash obtained from sugarcane bagasse (SCBA) which is rich in silica content, reduces the CO2 emission for Sustainable Development [5]. Sugar mills create approximately 03 tons of sugarcane bagasse from 10 tons of crushed

sugarcane. Burning bagasse occurs between 500 and 550 degrees Celsius (0 C) to produce SCBA. India accounts for roughly 20% of global sugar cane bagasse production. Bagasse is used as a heat source, resulting in an ash content of 8–10%, which is discarded. Numerous investigations on the usage of SCBA in concrete have come as a drop in bagasse disposal issues as well as environmental risks [6]. The other siliceous and rich in calcium material utilized as part substitution of cement in concrete is MK [7]. MK is distinguished kaolin clay which is manufactured through the calcination of homegrown kaolin at a temperature of 6500 C for 1 h. MK is a highly pozzolanic material that reduces chloride diffusion [8]. A detailed review is carried out in this study before experimental work on the process of using SCBA, MK, and CR in concrete as a fractional switch of cement and fine aggregate is explained below .

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LITERATURE REVIEW

Recycling waste rubber tyres in construction materials and associated environmental considerations by Abbas Mohajerani, Lucas Burnett, Farshid Maghool, Sukson Horpibulsuk. The recycling of waste rubber tires in construction materials presents a sustainable solution to the growing environmental concerns associated with tire disposal. In their review, Mohajerani et al. (2020) examine the potential applications of recycled rubber in construction, highlighting its benefits and challenges. Waste tires, if not properly managed, pose serious environmental hazards, including toxic chemical leaching, fire risks, and breeding grounds for pests. Integrating rubber into construction materials—such as concrete, asphalt, and lightweight aggregates—enhances flexibility, durability, and insulation properties. However, challenges like reduced compressive strength in concrete and potential environmental risks from rubber leachates require further research. While recycling tires in construction reduces landfill waste and promotes sustainability, Mohajerani et al. emphasize the need for rigorous environmental impact assessments to ensure long-term safety and effectiveness in infrastructure development. Enhancing shear resistance in pavement structures with crumb rubber modified asphalt gravel as a bonding layer by ,Dandan Yin, Lan Wang, Lin li. The use of crumb rubber-modified asphalt gravel (CRAG) as a bonding layer in pavement structures enhances shear resistance, improving overall road performance and durability. This modified layer acts as an adhesive interface between pavement layers, reducing delamination and improving load transfer efficiency. The incorporation of crumb rubber, derived from recycled tires, increases the elasticity and flexibility of the bonding layer, allowing it to absorb stresses and prevent shear-related failures such as slippage and rutting. Additionally, CRAG enhances pavement resilience under high traffic loads and varying temperature conditions, reducing maintenance costs and extending pavement lifespan. Proper mix design and compaction techniques are essential to maximize shear resistance while maintaining adequate bonding strength. The integration of crumb rubber in asphalt gravel not only strengthens pavement structures but also promotes sustainable road construction by repurposing waste materials. The incorporation of crumb rubber (CR) and reclaimed asphalt pavement (RAP) significantly influences the viscoelastic properties of asphalt mixtures, enhancing their performance and sustainability. Crumb rubber, derived from recycled tires, improves the elasticity and flexibility of asphalt, reducing thermal cracking and fatigue damage. Meanwhile, RAP, consisting of aged asphalt and aggregates, enhances stiffness and provides a cost-effective alternative to virgin materials. When combined, CR and RAP create a balanced mix that improves resistance to rutting while maintaining adequate flexibility. However, optimizing their proportions is crucial, as excessive RAP content may lead to increased stiffness and reduced workability. The synergistic effect of CR and RAP contributes to enhanced rheological behavior, extending pavement lifespan and promoting eco-friendly infrastructure by reducing waste and conserving natural resources. Crumb rubber asphalt mixtures by dry process: Assessment after eight years of use on a low/medium trafficked pavement by Luis G. Picado-Santos , Silvino D. Capitão , J.L. Feiteira Dias.Crumb rubber asphalt mixtures produced using the dry process have been widely explored for their potential benefits in pavement performance and sustainability. After eight years of use on a low-to-medium trafficked pavement, an assessment of these mixtures reveals key insights into their durability, resistance to aging, and overall effectiveness. Field evaluations indicate that the crumb rubber modification enhances flexibility, reducing the likelihood of cracking and improving resistance to deformation under varying weather conditions. Moreover, the long-term performance suggests that the rubberized asphalt maintains its structural integrity, offering an environmentally friendly alternative by repurposing waste tires while contributing to road longevity. However, factors such as mix design, traffic loads, and maintenance practices play a crucial role in determining the ultimate success of the pavement. These findings support the continued use of crumb rubber asphalt, particularly in roads with moderate traffic levels, as a sustainable and performance-enhancing solution. Road pavement rehabilitation using a binder with a high content of crumb rubber has shown significant benefits, particularly in noise reduction. The incorporation of crumb rubber enhances the viscoelastic properties of the binder, leading to a more flexible and resilient pavement surface. This improved elasticity helps to dampen vibrations and absorb sound energy generated by vehicle tires, resulting in lower traffic noise levels. Studies indicate that rubberized asphalt mixtures can effectively reduce noise pollution, especially in urban and residential areas where traffic sound is a concern. Additionally, the use of high- content crumb rubber binders contributes to sustainability by repurposing waste tires and extending pavement lifespan. While the degree of noise reduction depends on factors such as mix design, pavement texture, and traffic conditions, the overall impact highlights the potential of rubberized asphalt as a practical solution for quieter and more environmentally friendly roadways.

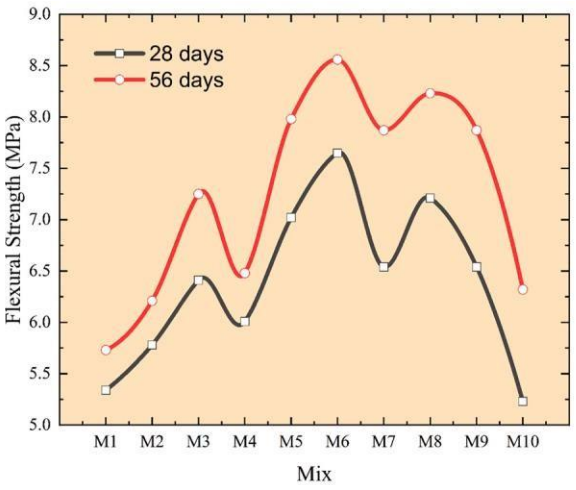
Life cycle assessment (LCA) applied to bituminous mixtures containing recycled materials, such as crumb rubber and reclaimed asphalt pavement (RAP), provides a comprehensive evaluation of their environmental impact. The incorporation of these recycled materials significantly reduces the consumption of virgin aggregates and bitumen, leading to lower energy use and greenhouse gas emissions during production. Crumb rubber enhances pavement performance by improving flexibility and durability, while RAP contributes to material conservation and cost savings. LCA studies highlight the benefits of these sustainable mixtures in reducing waste disposal and promoting circular economy practices in road construction. However, factors such as transportation distances, production methods, and long-term pavement performance influence the overall environmental footprint. By optimizing mix designs and recycling processes, the integration of crumb rubber and RAP in asphalt mixtures offers a viable pathway toward more eco-friendly and resource-efficient infrastructure

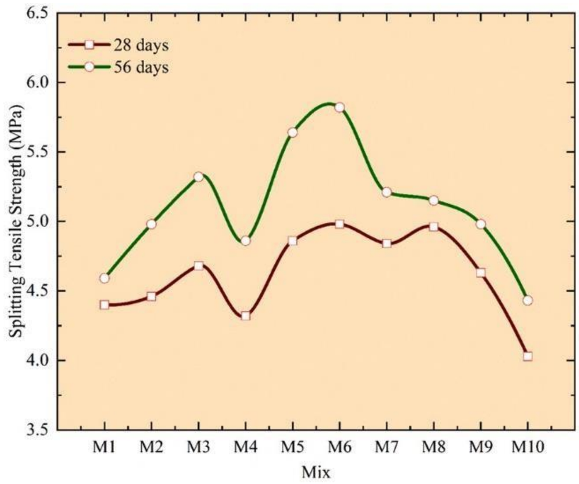
PROPOSE METHODOLOGY

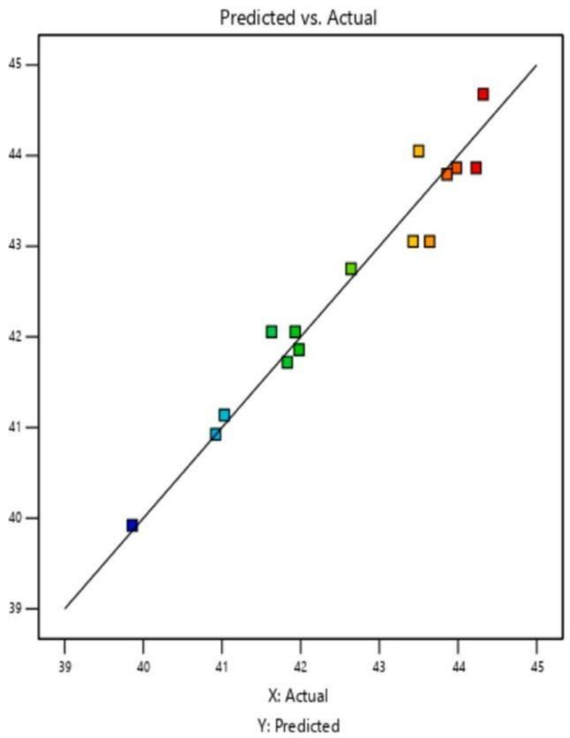
Material Selection – Identifying appropriate crumb rubber size and content.
Mix Design – Developing rubber-modified asphalt mixtures with optimal performance characteristics. Performance Testing – Evaluating durability, elasticity, and resistance to environmental factors.
Application & Construction – Proper blending and placement techniques for optimal pavement performance. Quality Control & Monitoring – Ensuring compliance with specifications and long-term performance assessment. Ambient ground rubber: Produced by mechanical grinding at room temperature.
Cryogenic ground rubber: Created by freezing and shattering rubber into fine particles. Common sizes: No. 10 (2 mm), No. 40 (0.425 mm), No. 80 (0.18 mm).
Typical content: 5% - 20% by weight of bitumen.

RESULTS

There are result we got during while using the crumb rubber in pavement design.







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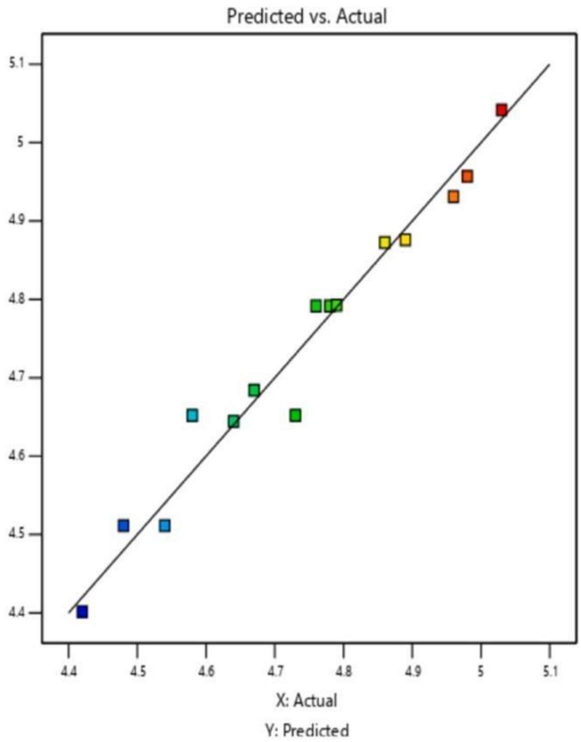

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CONCULSION

This experimental investigation aims to explore and optimize the eco-concrete composite by integrating three sustainable materials: sugarcane bagasse ash, metakaolin, and crumb rubber. By combining these materials, the study aims to develop a concrete mixture that not only offers enhanced mechanical properties but also contributes to environmental sustainability. The findings contributed to the development of eco-concrete composites that offer improved mechanical properties, reduced environmental impact, and enhanced sustainability, paving the way for greener and more durable construction materials. Based on the major findings of this study, the following conclusion points were briefly highlighted.

The concrete composite density was significantly lowered by employing CR, with SCBA and MK having less of an impact. It is found that the MK and SCBA are partially substituted for CR in concrete, the slump values are higher than when CR is used. The use of CR and SCBA above 5% harmed workability. • The compressive, splitting tensile, and flexural strengths are initially increased and then decreased after utilizing MK, SCBA, and CR beyond 10%.

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