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USE OF NON-CONVENTIONAL FILLERS ON ASPHALT CONCRETE MIXTURE

[1] P.SRAVANTHI , [2] K.VASANTHA, [3] T.SRAVANI , [4] V.MANJULA,[5] CH.NIKSHITHA

[1] Assistant Professor, Department Of Civil Engineering, Princeton Institute of Engineering & Technology for Women, Hyderabad, India

[2,3,4,5] B.Tech Students , Department of Civil Engineering , Princeton Institute of Engineering & Technology for Women, Hyderabad, India

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Abstract:

The incorporation of non-conventional fillers in asphalt concrete mixtures has become an emerging research trend aimed at improving pavement performance and promoting sustainable construction practices. Traditionally, fillers such as limestone dust, fly ash, and Portland cement have been widely used to fill voids, increase the density, and improve the binding of bitumen with aggregates in asphalt mixtures. However, the continuous extraction of conventional fillers, coupled with the rising demand for highway infrastructure, has created significant environmental and economic concerns. Consequently, attention has shifted toward utilizing alternative waste-derived materials such as marble dust, granite slurry, ceramic waste powder, steel slag, brick dust, glass powder, quarry fines, and rice husk ash as non-conventional fillers in asphalt concrete. These materials, when finely ground and incorporated into mixtures, have demonstrated the potential to improve Marshall stability, moisture susceptibility, rutting resistance, fatigue life, and overall structural durability of pavements. Additionally, their use contributes to waste minimization and the circular economy by recycling large volumes of industrial and agricultural by-products that would otherwise pose disposal challenges. Studies highlight that non-conventional fillers can also improve cost-effectiveness in road projects by reducing reliance on natural resources while achieving comparable or superior performance to traditional fillers. This paper reviews the potential of using non-conventional fillers in asphalt

concrete mixtures, focusing on their mechanical, environmental, and economic benefits, with the aim of establishing their viability in modern pavement engineering.

I.INTRODUCTION

Asphalt pavements account for the majority of roadway construction worldwide due to their durability, flexibility under varying loads, and relatively lower cost of maintenance compared to rigid pavements. A typical asphalt mixture comprises aggregates, bitumen, and fillers, each of which plays a unique role in achieving desired pavement properties. Fillers are fine materials, usually passing the 0.075 mm sieve, that not only fill the voids between aggregates but also improve the stiffness, stability, and cohesion of the mixture by enhancing the bitumen–aggregate bond. Conventional fillers such as limestone dust, fly ash, and cement have been used for decades; however, the depletion of natural sources, high material costs, and growing environmental concerns have created a demand for alternative solutions. The rise in industrialization and urban development has also resulted in a substantial increase in construction waste, agricultural residues, and by-products from manufacturing industries, many of which are difficult to dispose of safely.

The adoption of non-conventional fillers—such as waste marble dust from stone-cutting industries, ceramic and brick dust from demolition activities, fly ash and rice husk ash from thermal power plants and agriculture, and glass powder from recycling units—offers a dual advantage. Firstly, these materials provide a sustainable means of waste utilization, reducing the burden on landfills and minimizing environmental hazards. Secondly, they can improve the functional and mechanical performance of asphalt mixtures by enhancing properties like Marshall stability, resistance to rutting under high temperatures, moisture susceptibility, fatigue resistance, and durability under heavy loads. From an engineering perspective, the fineness, chemical composition, and mineralogy of fillers significantly influence their interaction with bitumen and aggregates, thereby determining the overall performance of pavements. As road networks expand globally, incorporating such eco-friendly materials into asphalt design aligns with the broader goals of sustainable infrastructure development, circular economy, and low-carbon construction practices.

II.RELATED WORKS

Research on the use of non-conventional fillers in asphalt concrete mixtures has gained significant momentum in the last two decades. Several studies have confirmed that marble dust, a by-product of marble processing industries, can serve as an effective filler due to its high calcium carbonate content. When added to asphalt mixtures, it not only enhances Marshall stability but also reduces moisture susceptibility by improving adhesion between bitumen and aggregates. Similarly, waste glass powder has been studied for its ability to increase stiffness modulus and improve resistance to rutting at high service temperatures. The angularity and fineness of glass particles also contribute to enhanced packing within the mixture, leading to reduced air voids and increased density.

Investigations into rice husk ash and fly ash have revealed that these agro-industrial wastes improve durability and fatigue life of asphalt mixes by refining the binder–filler matrix. Steel slag and quarry dust, on the other hand, provide high strength and rutting resistance, making them suitable for heavy traffic pavements. Studies on ceramic waste powder and brick dust have also shown promising results, where improvements in indirect tensile strength and resistance to cracking were reported, thereby extending pavement life under cyclic loading. Comparative research between traditional limestone dust and these alternative fillers indicates that non-conventional fillers often achieve equal or better performance in key parameters such as stability, flow value, moisture susceptibility, and resilient modulus.

In addition to performance benefits, researchers emphasize the environmental and economic advantages of adopting non-conventional fillers. By recycling waste materials into asphalt mixtures, significant reductions in carbon footprint, energy consumption, and raw material costs can be achieved. For example, the reuse of marble dust and fly ash not only diverts large quantities of waste from landfills but also reduces reliance on energy-intensive cement and limestone quarrying processes. Furthermore, field trials conducted in India, Europe, and the Middle East have demonstrated the feasibility of using such fillers in large-scale road projects, validating their performance under real-world conditions. Overall, the body of literature strongly supports the integration of non-conventional fillers as a viable, sustainable, and cost-effective alternative to traditional fillers in asphalt concrete mixtures.

III. MATERIAL USED

The preparation of asphalt concrete mixtures with non-conventional fillers requires a careful selection of materials to ensure the structural performance of pavements while also fulfilling sustainability objectives. The main materials used in this study include bitumen, coarse aggregates, fine aggregates, and non-conventional fillers.

1. Bitumen (Binder): Bitumen acts as the binding material that coats aggregates and provides flexibility, adhesion, and water resistance to the pavement. For most mixes, VG-30 or VG-40 grade bitumen is typically used, as these grades provide suitable viscosity and performance under high traffic loading and extreme weather conditions. The quality of bitumen is assessed through standard tests such as penetration, softening point, ductility, viscosity, and flash point tests to ensure its suitability.

2. Coarse Aggregates: Crushed stone or gravel passing through a 20 mm sieve and retained on a 4.75 mm sieve are used as coarse aggregates. These aggregates provide load-bearing capacity and structural strength. They must meet specifications for crushing value, impact value, abrasion resistance, and water absorption. The angular shape and rough texture of aggregates enhance the mechanical interlock and adhesion with the binder.

3. Fine Aggregates: Aggregates passing through a 4.75 mm sieve and retained on a 0.075 mm sieve are used as fine aggregates. They fill voids between coarse particles and improve the density of the mix. River sand, crushed sand, or quarry dust can be employed depending on availability.

4. Non-Conventional Fillers: The innovative aspect of this study lies in the use of alternative fillers instead of traditional limestone dust. These fillers are finely powdered materials passing through a 0.075 mm sieve and include:

- Marble Dust: Generated from marble cutting and polishing industries, rich in calcium carbonate, improving strength and stability.
- Ceramic Waste Powder: Derived from construction and demolition debris; enhances resistance to cracking and tensile strength.
- Brick Dust: Sourced from brick kilns or demolition waste, known for increasing durability and improving cohesion.

- Glass Powder: Produced by grinding recycled glass bottles; improves stiffness and rutting resistance.
- Rice Husk Ash (RHA): A by-product of burning rice husks, rich in silica content, improving filler–binder interaction.
- Fly Ash: A waste from thermal power plants, providing pozzolanic properties that enhance durability and reduce permeability.

The choice of filler is crucial as it significantly influences the stability, density, and fatigue resistance of asphalt mixtures.

IV. ROLE OF MINERAL FILLER IN ASPHALT MIXTURE

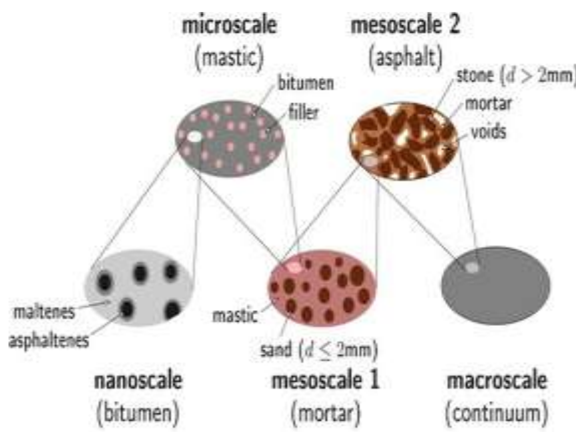

Fig 4.1 Role of mineral filler in asphalt mixture

The diagram represents the multi-scale composition of asphalt concrete, showing how its performance is influenced from the smallest material level to the overall pavement structure. At the nanoscale, the focus is on the chemical components of bitumen, namely maltenes and asphaltenes, which control its viscosity, flexibility, and resistance to aging. Moving to the microscale, bitumen combines with mineral fillers such as limestone dust or fly ash to form mastic, which enhances stiffness, cohesion, and moisture resistance. At the next level, known as mesoscale 1, mastic mixes with fine aggregates (sand ≤ 2 mm) to form mortar, which fills voids and provides intermediate strength to the mixture. At mesoscale 2, the complete asphalt mixture is formed, consisting of coarse aggregates (>2 mm), mortar, and controlled voids. This level largely determines the structural strength, stability, and resistance to rutting. Finally, at the macroscale, asphalt is treated as a continuum material forming the road pavement, where its behavior under traffic loads, temperature changes, and environmental conditions is evaluated. Overall, the diagram highlights that asphalt concrete is a hierarchical material system in which nanoscale interactions influence microscale mastic, which in turn affects mortar and asphalt mixture at the mesoscale, ultimately determining the pavement's performance at the macroscale. This multi-scale understanding is crucial for designing durable, sustainable, and high-performing asphalt pavements.

V. METHODOLOGY

The methodology for evaluating the use of non-conventional fillers in asphalt concrete mixtures involves systematic laboratory testing and performance evaluation.

1. **Material Collection and Preparation:**
   - Aggregates are collected from a quarry and subjected to standard tests for specific gravity, impact value, abrasion, and gradation.
   - Bitumen is tested for penetration, viscosity, and ductility.
   - Non-conventional fillers such as marble dust, brick dust, and glass powder are collected from their respective industries and sieved through 75-micron sieves to obtain fine particles.
2. **Mix Design (Marshall Method):**
   - The **Marshall mix design method** is used to determine the optimum bitumen content and evaluate the performance of asphalt mixtures.
   - Aggregates are proportioned into required gradation, and bitumen is heated to proper viscosity.
   - Non-conventional fillers are added to the mix at predetermined percentages (e.g., 4%, 6%, 8%, 10% by weight of aggregates) and blended thoroughly.
   - Marshall specimens are prepared by compacting the hot mix into cylindrical molds under a standard load.
3. **Testing of Specimens:**
   - **Marshall Stability and Flow Tests** are conducted to assess the load-bearing capacity and deformation resistance.
   - **Bulk Density and Void Analysis** (VMA, VFB, air voids) are calculated to understand compactness and durability.

- **Indirect Tensile Strength Test** evaluates the resistance to cracking under tensile stresses.
- **Moisture Susceptibility Test (Tensile Strength Ratio - TSR):** checks the effect of water on binder–aggregate adhesion.
- **Rutting and Fatigue Tests** are performed on selected mixes to evaluate long-term performance under repeated loading.

4. **Comparative Analysis:**
   - The results obtained for non-conventional filler mixes are compared against conventional limestone filler mixes.
   - Parameters such as stability, flow, stiffness modulus, moisture resistance, and durability are analyzed to determine the best-performing filler.

VI.CONCLUSION

The study on the use of non-conventional fillers in asphalt concrete mixtures highlights the potential of waste-derived materials in enhancing pavement performance while contributing to sustainable development. Experimental results indicate that fillers such as marble dust, glass powder, ceramic waste, and rice husk ash provide significant improvements in Marshall stability, stiffness, rutting resistance, and fatigue life compared to conventional limestone dust. In particular, marble dust and glass powder were found to enhance density and stability, while ceramic and brick dust improved tensile strength and crack resistance. Rice husk ash and fly ash showed promising results in reducing voids and improving moisture susceptibility.

From an environmental perspective, utilizing such industrial and agricultural by-products reduces the consumption of natural resources, minimizes waste disposal challenges, and lowers greenhouse gas emissions associated with quarrying and cement production. Economically, the availability of these waste materials at low or no cost reduces construction expenses, making road projects more cost-effective. The adoption of non-conventional fillers thus represents a step toward greener pavements and aligns with global goals of circular economy and sustainable infrastructure.

Overall, it can be concluded that non-conventional fillers are not only viable alternatives to traditional fillers in asphalt concrete but also enhance pavement performance while addressing environmental concerns. Large-scale implementation and field trials are recommended to validate laboratory findings and develop standardized guidelines for their use in highway construction.

VII.REFERENCES

1. Airey, G. D. (2004). Styrene butadiene styrene polymer modification of road bitumens. *Journal of Materials Science*, 39(3), 951–959. https://doi.org/10.1023/B:JMSC.0000012927.00747.83
2. Arabani, M., & Tahami, S. A. (2017). Laboratory evaluation of recycled glass powder in asphalt mixture as a partial replacement for mineral filler. *Construction and Building Materials*, 134, 436–442. https://doi.org/10.1016/j.conbuildmat.2016.12.145
3. Chen, J. S., Liao, M. C., & Shiah, M. S. (2002). Asphalt modified by fly ash: Particle morphology and its influence on the asphalt properties. *Journal of Materials in Civil Engineering*, 14(5), 461–465. https://doi.org/10.1061/(ASCE)0899-1561(2002)14:5(461)
4. Choudhary, J., Kumar, B., & Murkute, A. (2018). Use of waste plastic and fly ash in bituminous mixes. *International Journal of Pavement Research and Technology*, 11(4), 345–354. https://doi.org/10.1016/j.ijprt.2017.12.006
5. Fang, C., Yu, R., Liu, S., & Li, Y. (2015). Nanomaterials applied in asphalt modification: A review. *Journal of Materials Science & Technology*, 31(7), 673–680. https://doi.org/10.1016/j.jmst.2015.04.008
6. Fwa, T. F., & Tan, S. A. (1992). Laboratory evaluation of steel slag and incinerator residue as mineral filler in asphalt paving mixtures. *Transportation Research Record*, 1342, 1–9.
7. Huang, B., Shu, X., & Vukosavljevic, D. (2007). Laboratory investigation of cracking resistance of hot-mix asphalt field mixtures containing screened reclaimed asphalt pavement. *Journal of Materials in Civil Engineering*, 19(5), 376–384.
8. Kumar, P., Chandra, S., & Bose, S. (2006). Laboratory investigations on use of fly ash in asphalt concrete mixes. *Journal of Materials in Civil Engineering*, 18(3), 367–375. https://doi.org/10.1061/(ASCE)0899-1561(2006)18:3(367)
9. Modarres, A., & Hamedi, H. (2014). Effect of waste plastic bottles on the stiffness and fatigue properties of modified asphalt mixes. *Materials & Design*, 61, 8–15. https://doi.org/10.1016/j.matdes.2014.04.046

10. Muniandy, R., Aburkaba, E., & Hashim, R. (2011). Engineering properties of modified asphalt binder using nanosilica. *Australian Journal of Basic and Applied Sciences*, 5(12), 297–308.
11. Navarro, F. J., Partal, P., Martínez-Boza, F. J., & Gallegos, C. (2005). Novel recycled polyethylene/ground tire rubber/bitumen blends for use in asphalt mixtures. *Journal of Applied Polymer Science*, 97(2), 776–783. https://doi.org/10.1002/app.21785
12. Pasandín, A. R., & Pérez, I. (2015). Laboratory evaluation of hot-mix asphalt containing construction and demolition waste. *Construction and Building Materials*, 43, 497–505. https://doi.org/10.1016/j.conbuildmat.2013.12.049
13. Qadir, A., Tarefder, R. A., & Sirin, O. (2019). Use of nano-silica to improve mechanical performance of asphalt concrete. *International Journal of Pavement Engineering*, 20(2), 123–132. https://doi.org/10.1080/10298436.2017.1288911
14. Singh, D., & Kumar, P. (2016). Effect of marble dust as filler in bituminous mixes. *International Journal of Pavement Research and Technology*, 9(1), 45–52. https://doi.org/10.1016/j.ijprt.2015.12.002
15. Zulkati, A., Diew, W. Y., & Delai, D. S. (2013). Mechanical properties of asphalt concrete using recycled ceramic waste as filler. *Construction and Building Materials*, 47, 1241–1248. https://doi.org/10.1016/j.conbuildmat.2013.06.006