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Review RTCET

Replacement of Fine Aggregate in Concrete Using Bakelite Powder: A Review

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Abstract

This review explores the feasibility of incorporating Bakelite, a thermosetting synthetic polymer known for its durability, heat resistance, and insulating properties, as a partial replacement for fine aggregate in concrete. The increasing focus on sustainable construction practices has driven interest in utilizing industrial waste materials like Bakelite to reduce environmental pollution while enhancing concrete performance. Bakelite, often discarded as industrial waste, presents an opportunity to improve the mechanical and durability properties of concrete mixtures when used as a substitute for traditional fine aggregate. This study examines the influence of Bakelite on key properties of concrete, including workability, compressive strength, and resistance to aggressive environmental conditions. Research findings suggest that while the inclusion of Bakelite enhances properties such as compressive strength and durability, challenges in achieving optimal workability may arise due to its material characteristics. The review evaluates the performance of Bakelite in various concrete mixes, with a particular focus on its application in M25 grade concrete, which is widely used in construction. The investigation aims to determine whether Bakelite can significantly improve the compressive strength and durability of concrete without compromiing other essential properties. The analysis also highlights areas for further research, such as optimizing mix proportions and addressing potential limitations related to compaction and workability. Ultimately, this study contributes to advancing the understanding of Bakelite's potential as a sustainable and effective material in concrete production.

Keywords: Bakelite waste, fine aggregate, concrete, compressive strength, durability, m25 grade, sustainable construction, industrial waste

INTRODUCTION

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Bakelite Is a Thermosetting Plastic Produced Through the Polycondensation Reaction of Phenol and Formaldehyde. This Material Has Been Widely Utilized in The Manufacturing of Telephone Casings, Automotive Components, Electrical Insulators, And Heat-Resistant Cooking Tools. The Increasing Use of Bakelite, Especially in Industries Such as Automotive and Consumer Goods, Has Led to A Rise in Bakelite Waste. Open Burning or Direct Landfilling of Bakelite Waste Is Prohibited Due to Its Environmental Implications. Bakelite Was First Developed In 1907 By Leo Hendrik Baekeland, A Belgian-American Scientist. It Is a Cross-Linked Polymer Often Sourced as Waste from Workshops, Such as Those in Signal and Telecommunication Sectors [1-5].

The reuse of industrial waste materials, like Bakelite, as secondary resources has become a crucial strategy for reducing environmental impacts and promoting sustainability. The construction industry, in particular, has explored ways to incorporate such waste into concrete production to create sustainable alternatives. Studies have highlighted the potential for reusing these materials in concrete manufacturing, offering environmental and structural benefits [6-10].

As a thermosetting plastic, Bakelite cannot be remelted to create new products, and its disposal via landfilling or burning contributes to significant environmental issues, including air, water, and soil pollution. The material also poses health risks due to the presence of harmful compounds like methyl and ethyl alcohol. To prepare Bakelite waste for reuse, it is subjected to a process involving purification, shredding, melting, pelletization, and conversion into powder, making it suitable for various applications as a filler material [11].

MATERIAL AND PROPERTIES

Bakelite

Bakelite, Chemically Known as Polyoxybenzylmethylenglycolanhydride, Is A Phenol-Formaldehyde Resin Formed Through a Condensation Reaction. Its Chemical Formula Is (C6h6o·Ch2o). Invented In 1903 By Chemist Leo Hendrik Baekeland, This Thermosetting Material Is Characterized by Its Heat Resistance and Durability. Once Melded, Bakelite Undergoes Irreversible Solidification, Making It Unsuitable for Remelting or Reshaping [12-14].

Bakelite's resilience to various chemicals, including acids and solvents, makes it a preferred material for applications such as gear wheels, brake linings, and other heat-resistant automotive components. despite its beneficial properties, Bakelite contains toxic compounds such as phenol, methyl, and ethyl alcohols, which pose environmental and health hazards Figure 1,2 [15-17].

[Note- Review- Using Ground Bakelite as a Substitute for Fine Aggregate, International Journal for Research in Applied Science & Engineering Technology, Volume 11, Issue X, October 2023, ISSN: 2321-9653]

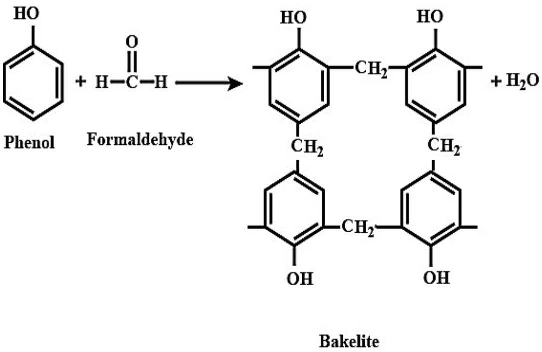

Figure 1. Chemical structure of bakelite.

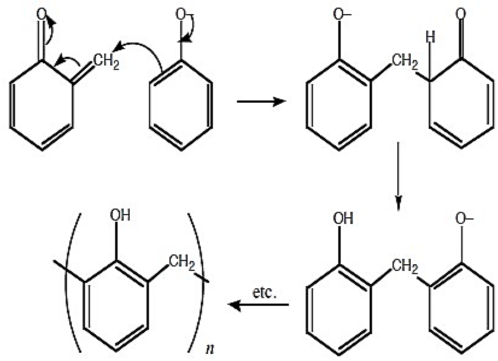

Figure 2. Bakelite's structure.

POPERTIES OF BAKELITE

- *Cross-linked polymer*: Bakelite forms a strong three-dimensional structure
- *Non-Remel table***:** It cannot be melted again after molding
- *Thermal resistance***:** It withstands elevated temperatures effectively.
- Chemical heat, and electrical resistance**:** Resistant to corrosive chemicals and electrical conductivity.
- *Strength and lightweight***:** Bakelite is sturdy, rigid, and lightweight, making it ideal for various applications.

Fine Aggregate

Fine aggregate, comprising granular materials like crushed stone or sand, is a crucial ingredient in concrete. Its quality and density significantly influence the hardened concrete's properties. The fine aggregate used in this study is river sand, cleaned and screened to remove organic or inorganic contaminants. It passes through a 2.37 mm sieve and is essential for ensuring proper grading in construction applications [18-20].

Properties of Fine Aggregate

- Gradation and Particle
- Size Specific Absorption and Gravity
- Chemical Stability
- Durability

Coarse Aggregate

Coarse aggregate refers to material retained on a 4.75 mm BIS test sieve, often fractured stone. In this study, locally available coarse aggregates with a maximum size of 20 mm were used. These aggregates were cleaned to eliminate dust and debris and tested according to IS: 2386-1963 [21-23].

Properties of Coarse Aggregate

- *Property description*: Size & Gradation Ranges from 4.75 mm to 80 mm, impacting workability, strength, and mix design. Shape Can be rounded, uneven, or angular; angular aggregates improve bond strength. Surface Texture Smooth or rough; rough surfaces enhance cement bonding. Strength Capacity to withstand crushing; stronger aggregates result in stronger concrete. Specific Gravity Ratio of mass to water volume; higher specific gravity indicates denser and stronger concrete. Water Absorption Amount of water absorbed; high absorption reduces workability [24-26].

Cement

Cement is a finely powdered material composed of silica, limestone, clay, and shells. It serves as a binder in concrete and mortar, creating a paste when mixed with water that solidifies over time. Portland cement, made by heating limestone and clay to form clinker and then grinding it into powder, is the most commonly used type in construction [27-30].

Properties Of Cement

Property Value

1. Specific Gravity 3.15
2. Fineness 8.56%
3. Initial Setting Time 30 minutes
4. Final Setting Time 10 hours

LITERATURE REVIEW

Bakelite powder, as a substitute for fine aggregate, can replace up to 20% of natural sand in concrete without compromising compressive strength. The ideal replacement is 15%, where compressive strength increases the most. Substituting up to 10% coarse aggregate with Bakelite enhances concrete's compressive strength and solid block density. Bakelite waste, replacing 2-4% fine aggregate, increases compressive strength compared to normal concrete, indicating potential in the construction industry. Bakelite improves strength and durability when used as a partial replacement for aggregates, providing a sustainable, lightweight alternative in construction. Up to 20% replacement of fine aggregate with Bakelite waste in M25 grade concrete maintains compressive strength, but beyond 20%, performance decreases. Replacing fine aggregate with Bakelite powder yields the best compressive strength at 24.51 MPa with an optimal substitution ratio. Using E-plastic waste, including Bakelite, as a partial replacement for fine aggregates offers environmental benefits and reduces dependency on conventional resources.

CONCLUSION

The workability of concrete decreases as Bakelite content increases. Replacing up to 15% fine aggregate with Bakelite improves compressive strength. The maximum compressive strength achieved is 27.4 MPa at 15% replacement, compared to 25.2 MPa for normal concrete. Up to 20% fine aggregate can be replaced with Bakelite in M25 concrete without compromising compressive strength. Beyond 20%, the compressive strength drops below 25 MPa. Increasing Bakelite content reduces the compaction factor of concrete.

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