

A LITERATURE REVIEW ON EXPERIMENTAL EVALUATION OF CONCRETE STRENGTH BY PARTIAL REPLACEMENT OF CEMENT BY SAWDUST ASH AND ADDITION OF POLYPROPYLENE FIBER AND STEEL FIBER

Abdul Soyeb Sheikh¹, Prof. Dr. Valsson Varghese²

¹M-Tech Student, K. D. K. College Of Engineering, Nagpur, India.

²Professor K. D. K. College Of Engineering, Nagpur, India.

ABSTRACT

Concrete, being one of the most widely used construction materials, is constantly under scrutiny for improvements in terms of strength, durability, and sustainability. This experimental study investigates the effects of partial replacement of cement with sawdust ash, as well as the combined influence of polypropylene fiber and steel fiber additions on the strength characteristics of concrete. The research involves the formulation of various concrete mixes with different proportions of sawdust ash as a partial substitute for cement. Additionally, varying concentrations of polypropylene fiber and steel fiber are introduced into the mix to evaluate their impact on the mechanical properties of the concrete. The study aims to explore the potential benefits of incorporating these sustainable materials in concrete production. Concrete specimens are cast and subjected to a comprehensive testing program, including compressive strength, flexural strength, and split tensile strength tests. The workability of the concrete mixes is also assessed through slump tests. The experimental results are analyzed and compared with control samples to determine the influence of the individual and combined additives on the overall performance of the concrete.

Keyword: Concrete Strength, Sawdust Ash, Partial Replacement, Cement, Polypropylene Fiber, Steel Fiber

1. INTRODUCTION

Concrete, as a fundamental building material, plays a pivotal role in the construction industry due to its versatility, durability, and widespread use. However, the environmental impact of traditional concrete production, characterized by high cement content, has led to increased interest in sustainable alternatives. This study focuses on the experimental evaluation of concrete strength by exploring the combined effects of partial replacement of cement with sawdust ash and the incorporation of polypropylene fiber and steel fiber.

Background: Traditional concrete production is associated with significant carbon emissions and energy consumption during cement manufacturing. Researchers and engineers are actively seeking ways to enhance the sustainability of concrete while maintaining or improving its mechanical properties. The utilization of alternative materials, such as industrial by-products and fibers, has emerged as a promising avenue for achieving this balance.

Cement Replacement with Sawdust Ash: Sawdust ash, a by-product of the wood industry, offers a potential solution to reduce the environmental impact of concrete production. By partially replacing cement with sawdust ash, not only can the demand for cement be decreased, but also a waste material can be repurposed, contributing to a more sustainable construction industry.

Polypropylene and Steel Fiber Reinforcement: In addition to the cement replacement strategy, the study investigates the effects of reinforcing concrete with polypropylene fiber and steel fiber. Fiber reinforcement has been proven to enhance the mechanical properties of concrete by improving its tensile strength, ductility, and crack resistance. The combination of these fibers with sawdust ash may lead to synergistic effects, creating a composite material with superior performance.

Objectives of the Study:

The primary objectives of this experimental investigation are:

- To assess the influence of different levels of sawdust ash as a partial replacement for cement on the overall concrete strength.
- To explore the individual and combined effects of polypropylene fiber and steel fiber on the mechanical properties of concrete.
- To analyze the workability of concrete mixes with varied compositions.

Significance of the Research: This research holds significant implications for sustainable construction practices. If successful, the study could contribute to the development of eco-friendly concrete mixes with reduced cement content, enhanced strength, and improved resistance to cracking. The findings may pave the way for more environmentally conscious construction practices, aligning with global efforts toward sustainable development.

2. LITERATURE REVIEW

1. **Improved Fly Ash Based Structural Foam Concrete with Polypropylene Fiber, Alexey Beskopylny, Evgeniy Shcherban, Sergey A. Stel'makh, Levon Mailyan,** this work was to create and optimize the recipe technological parameters to produce non-autoclaved fiber foam concrete (FFC) using FA as a component. The study used standardized methods for assessing the properties of FFC, and the method of optical microscopy to analyze the structural characteristics of the material. It has been revealed that the replacement of cement with FA in an amount of 10% to 40% helps to reduce the dry density (DD) of FFC. The lowest DD was recorded for samples with 40% FA. The best results for the compressive strength (CS) and flexural strength (FS) were recorded for FFC samples with 10% FA instead of cement. The increase in CS was 12%, and the increase in FS was 23%. The best thermal insulation properties of FFC, and in terms of resistance to freezing and thawing, were recorded in samples with a 10% replacement of cement with FA. The maximum decrease in thermal conductivity was 14%.
2. **An Experimental Study on Strength of Concrete Using Areca Nut Husk Fiber and Partial Replacement of Cement by Granite Powder, B. K., N. M, Manoj Kumar K,** In this experimental investigation, various concrete mixtures were prepared by replacing cement with GP at different percentages (10%, 20%, 30%). Additionally, ANHF was added to the concrete mixtures in proportion 0.5% by weight of cube and cylinder to assess its impact on the mechanical properties of concrete. The properties examined included compressive strength and split tensile strength. The results of the experiments revealed that the inclusion of ANHF in the concrete mixture led to a significant improvement in the strength properties. Concrete specimens containing ANHF exhibited enhanced compressive and split tensile strengths compared to the control samples without ANHF. Furthermore, the addition of GP as a partial replacement for cement resulted in improved strength characteristics. The findings of this study highlight the potential of using waste materials such as ANHF and GP as viable alternatives in concrete production. The incorporation of ANHF can effectively enhance the strength properties of concrete, while the partial replacement of cement with GP offers both environmental and economic benefits. These results contribute to the sustainable development of the construction industry by reducing the reliance on conventional materials and promoting the utilization of waste by-products
3. **Sawdust-Based Concrete Composite-Filled Steel Tube Beams: An Experimental and Analytical Investigation, Ammar N. Hanoon, Mahir M. Hason, Amjad Ali K. Sharba, Ali A. Abdulhameed** Incorporating waste byproducts into concrete is an innovative and promising way to minimize the environmental impact of waste material while maintaining and/or improving concrete's mechanical characteristics and strength. The proper application of sawdust as a pozzolan in the building industry remains a significant challenge. Consequently, this study conducted an experimental evaluation of sawdust as a fill material. In particular, sawdust as a fine aggregate in concrete offers a realistic structural and economical possibility for the construction of lightweight structural systems. Failure under four-point loads was investigated for six concrete-filled steel tube (CFST) specimens. The results indicated that recycled lightweight concrete performed similarly to conventional concrete when used as a filler material in composite steel tube beams. The structural effects of sawdust substitution on ultimate load and initial stiffness were less substantial than the relative changes in the material properties, and the ultimate capacity of the tested samples decreased moderately as the substitution percentage of sawdust increased. Moreover, the maximum load capacity was observed to decrease by 6.43–30.71% for sawdust replacement levels between 5% and 45.1% across all tested samples. Additionally, when using lightweight concrete with 5% sawdust, the moment value of the CFST sample was reduced by 6.4%. Notably, the sawdust CFST samples exhibited a flexural behavior that was relatively comparable to that of the standard CFST samples.
4. **Experimental study on bonding performance of polypropylene fiber modified rubber concrete and deformed steel bar, Chenhui Zhu,** In order to study the binding properties of deformed steel rods and rubber concrete modified with polypropylene fiber, four groups of bonding specimens were designed with polypropylene fiber volume ratio as a variable. The effect of polypropylene fiber on bond strength and bond slip curve was investigated by drawing test. It was found that the bond strength increased with the increase of polypropylene fiber volume fraction in the range of 0 ~ 1.5 %. Based on the experimental data, the constitutive relationship between deformed steel bar and polypropylene fiber modified rubber concrete was established. It provides a theoretical basis for further research on polypropylene fiber modified rubber concrete.
5. **Experimental Studies on Hybrid Fiber Reinforced Concrete Utilizing Polypropylene Fiber and Natural Fiber,** The construction industry is responsible for the depletion of large amounts of non-renewable resources. This activity generates not only millions of tons of mineral wastes but also carbon dioxide gas emissions. More building materials based on renewable resources such as natural fibers are needed. This chapter discusses the utilization of natural fibers for concrete reinforcement. It covers the compatibility between the fibers and the cement matrix and

also how the fibers influence cement properties. It also includes the properties and durability performance of concrete reinforced with natural fibers. This paper presents an overview of the effect of polypropylene (PP) fibers on various properties of concrete in fresh and hardened state such as compressive strength, tensile strength, flexural strength, workability, bond strength, fracture properties, creep strain, impact and chloride penetration. The role of fibers in crack prevention has also been discussed.

6. **The Effect of Polypropylene Fiber and Steel Fiber on Geopolymer Concrete, Iman Satyarno, Suprpto Siswosukarto** One of the environmentally friendly concrete as an alternative to cement concrete in the future is geopolymer concrete which used a cement substitute in the form of fly ash. To prevent premature cracking of the concrete, this study added fiber types such as polypropylene fiber, and steel fiber (dramix), this experiment with 3 variables namely the addition of polypropylene fiber by 0%, 0.40%, 0.80%, 1.2%, steel fiber of 0.25%, 0.50%, 0.75%, 1.00%, as well as a combination of polypropylene fiber and steel fiber (0.4%P;0.50%D), (0.8%P;0.75%D), (1.2%P;1.00%D) of the weight of the concrete. In this study, using a beam specimen measuring 10x10x50 cm, for each percentage of fiber usage there are 2 beam trials. Geopolymer concrete in this study uses a ratio of NaOH and Na₂SiO₃ is 2:1 and a constant concentration of 10 Molar, to test the Flexural Strength Test of Concrete at the age of 28 days of concrete. The results of the highest average flexural strength of geopolymer concrete without fiber $\sigma_l = 78.77 \text{ kg/cm}^2$, using polypropylene 0.80% $\sigma_l = 50.50 \text{ kg/cm}^2$, and 0.25% steel fiber $\sigma_l = 68.87 \text{ kg/cm}^2$, the combination of both fibers (P0.4%; D0.25%) $\sigma_l = 65.34 \text{ kg/cm}^2$. These results do not produce good workability, thus affecting the decrease in flexural strength. By increasing the ratio A = 0.35 to 0.45, the geopolymer concrete mix produces better workability with the highest average flexural strength of geopolymer concrete with polypropylene fiber 0.8% $\sigma_l = 80.107 \text{ kg/cm}^2$.
7. **Combined effect of rice husk ash and fibers on the mechanical properties of concrete, Rameshkumar Kanagavel, Basanth Babu Koattaiveedu Mohanram, Sivasankar Sandrasekaran,** The concrete consists of various percentages of steel fibers and polypropylene fibers, and cement is partially replaced by rice husk ash with 8% by weight. At 0.5% and 1% by volume fraction, hooked end steel fibers were included. The fibrillated polypropylene fiber was added at 0.5% by weight fraction. At 28 and 56 days, cube compression test, split tensile strength test on cylinder and flexural strength tests on prism were performed. Optimal combination of steel and polypropylene hybrid fibers was evaluated from test findings. Results confirmed that the combination of RHA with fibers enhanced the concrete strength properties at 28 and 56 days curing periods. Concrete with hybrid form gave more strength than fiber in mono form. Among all the mixes considered in this investigation, hybrid mix 1% steel + 0.5% polypropylene fiber gave the highest compressive strength, split tensile strength and flexural strength at both 28 and 56 days curing periods. In this mix, the compressive strength was increased by 29% and 31% at 28 and 56 days respectively than control concrete. The split tensile strength was increased by 38% and 46% at 28 and 56 days respectively than control concrete. The flexural strength was increased by 47% and 57% at 28 and 56 days respectively than control concrete. To validate the test results, statistical mathematical models were created. The results revealed that the empirical mathematical models are in concurrence with the actual test findings.
8. **Experimental Strength on Polypropylen Fiber Reinforced Concrete, K.G. Selvi, S. Karthi,** The paper presents research work of experimental investigation on polypropylene fiber reinforced concrete by replacing river sand to artificial sand with and without admixture. Use of fiber reinforce polymer in civil engineering increase rapidly. Various type of fiber is used such as glass, carbon, steel, asbestos, polyester and polypropylene. The various experimental investigations for determination of properties of polypropylene fiber are discussed in paper work. This paper presents the effect of polypropylene (PP) fibers on various properties of concrete such as compressive strength, tensile strength, workability, and fracture properties with various content of fiber(0% ,0.5%,1.0%,1.5%). The result of this present investigation indicates that by adding of 0.5% of polypropylene fiber shows maximum compressive and tensile strength.
9. **Improved Fly Ash Based Structural Foam Concrete with Polypropylene Fiber, Alexey Beskopylny, Evgeniy Shcherban, Sergey A. Stel'makh, Levon Mailyan** The aim of this work was to create and optimize the recipe technological parameters to produce non-autoclaved fiber foam concrete (FFC) using FA as a component. The study used standardized methods for assessing the properties of FFC, and the method of optical microscopy to analyze the structural characteristics of the material. It has been revealed that the replacement of cement with FA in an amount of 10% to 40% helps to reduce the dry density (DD) of FFC. The lowest DD was recorded for samples with 40% FA. The best results for the compressive strength (CS) and flexural strength (FS) were recorded for FFC samples with 10% FA instead of cement. The increase in CS was 12%, and the increase in FS was 23%. The best thermal insulation properties of FFC, and in terms of resistance to freezing and thawing, were recorded in samples with a 10% replacement of cement with FA. The maximum decrease in thermal conductivity was 14%.

- 10. Investigating the fresh and mechanical properties of wood sawdust-modified lightweight geopolymer concrete, N. Mehdi, Hafeez Ghazanfarah, Faridmer Iman, Ghasan Fahim Huseien,** the current study examined the feasibility of using sawdust as a natural fine and coarse aggregate substitution in fly ash (FA)-granulated blast furnace slag (GBFS) based geopolymer concrete. Four mixes with a different percentage of sawdust (25, 50, 75, and 100) substituting natural aggregate were designed to examine the effects of sawdust on fresh and hardened features of geopolymer concrete compared to those conventional FA-GBFS-based geopolymer concrete with natural aggregate. Sodium silicate (NS) and sodium hydroxide (NH) (with NS/NH ratio of 0.75) were utilized to dissolve the alumina silicate from FA and GBFS. Informational models were developed using an experimental dataset to estimate the compressive strength of geopolymer concrete mix designs. Besides, using the weight of the developed network, a global sensitivity (GS) analysis was developed to identify the sensitivity of compressive strength to the waste sawdust content. Test results confirmed that by substituting natural aggregate with 100% sawdust, there was around a 35% decrease in compressive strength. Nevertheless, the sound absorption coefficient was increased by an average of 38% in frequencies range between 1800 and 2500 HZ, and thermal conductivity decreased by around 4.5 times once the natural aggregate was substituted by 100% sawdust.
- 11. Experimental investigation of steel fibres and polypropylene fibres effect on Fibre reinforced concrete, Tempat Pemandian Jenazah Gedung Meneng,** The study is aimed to determine the effect of varying percentage of dosage of steel and polypropylene fibres in fresh concrete properties and find that optimum percentage of steel-polypropylene fibre which can enhance the more compressive strength, flexural strength and also reducing the crack initiation and reduction of shrinkage cracks . The results present that flexural and compressive strength characteristics influenced by steel and polypropylene fibres. Using steel fibres are found to be more effective for the enhancement of flexural strength characteristics and reducing cracks propagation. Two types of steel fibres namely crimped steel fibre and hooked end steel fibre are used separately with polypropylene fibres. The crimped steel fibre is more effective than the hooked end steel fibre. The workability is also affected by the addition of steel fibres. Workability is more affected by the crimped steel fibres than hooked steel fibres. The amounts of fibres in the SPFRC mixes are varied from 0.5–1% of the total volume of concrete. The variation is also carried out in the combination of steel and polypropylene fibres to enhance the properties of SPFRC Mixes. Steel fibre varies from 0.25–0.85% whereas polypropylene fibre varies from 0.15% and 0.25%. After all the tests carried out on the SPFRC samples, it showed the type of steel fibre to be preferred with Optimum Content of Fibre Mix is proposed.
- 12. Influence of rice husk ash and hybrid fiber on engineering properties of densified high-performance fiber-reinforced concrete, Duy-Hai Vo, Minh H. Nguyen, M. H. Nguyen, Chao-Lung Hwang.** This study was designed to investigate the mechanical properties of high-performance fiber-reinforced concrete (HFRC) produced using rice husk ash (RHA) and hybrid fiber (HF) in accordance with the densified mixture design algorithm (DMDA) mix design method. Samples were produced using RHA as a direct replacement for cement at 10%, 20%, and 30%. HF, comprising steel and polypropylene fibers, was added (by volume) to the 20% RHA group mixture to improve the HFRC sample properties. Based on the experimental results, higher RHA contents had a generally negative effect on the fresh properties of the HFRC mixtures. Compressive strength values ranged from 53 to 72 MPa with various RHA and HF content. RHA replacement levels up to 20% had an insignificant effect on the strength development and dynamic modulus of the HFRC samples. However, the addition of HF improved splitting tensile strength, flexural strength, and dynamic modulus remarkably at all curing ages. Furthermore, the 91-day drying shrinkage was in the ranges of 0.032%–0.039% and 0.023%–0.034% using different RHA and HF levels, respectively. Increasing both RHA and HF contents significantly reduced drying shrinkage in the samples. Multivariable regression was also performed, clarifying that all tested results were consistent and had good correlations. The results of this study also provide a potentially effective use for abundantly available industrial waste products such as fly ash (FA) and RHA to promote the production of greener and more sustainable concrete.
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- 14. Influence of rice husk ash and hybrid fiber on engineering properties of densified high-performance fiber-reinforced concrete, Duy-Hai Vo, Minh H. Nguyen, M. H. Nguyen, Chao-Lung Hwang,** This study was designed to investigate the mechanical properties of high-performance fiber-reinforced concrete (HFRC) produced using rice husk ash (RHA) and hybrid fiber (HF) in accordance with the densified mixture design algorithm (DMDA) mix design method. Samples were produced using RHA as a direct replacement for cement at 10%, 20%, and 30%. HF, comprising steel and polypropylene fibers, was added (by volume) to the 20% RHA group mixture to improve the HFRC sample properties. Based on the experimental results, higher RHA contents had a generally negative effect on the fresh properties of the HFRC mixtures. Compressive strength values ranged from 53 to 72 MPa with various RHA and HF content. RHA replacement levels up to 20% had an insignificant effect on the strength development and dynamic modulus of the HFRC samples. However, the addition of HF improved splitting tensile strength, flexural strength, and dynamic modulus remarkably at all curing ages. Furthermore, the 91-day drying shrinkage was in the ranges of 0.032%–0.039% and 0.023%–0.034% using different RHA and HF levels, respectively. Increasing both RHA and HF contents significantly reduced drying shrinkage in the samples. Multivariable regression was also performed, clarifying that all tested results were consistent and had good correlations. The results of this study also provide a potentially effective use for abundantly available industrial waste products such as fly ash (FA) and RHA to promote the production of greener and more sustainable concrete.

- 15. Utilization of sawdust composites in construction—a review, Bamidele Charles Olaiya, Mustapha Muhammad Lawan, Kolawole Adisa Olonade.** This study presents the use of sawdust ash as a substitute in the production of sustainable building materials. Inappropriate dispose of wood-waste causes serious environmental problems as it results in atmospheric degradation, emissions of greenhouse gases and the destruction of aquatic and organic products. This review article combines research results from past studies into the usage of sawdust as an alternative for essential elements in construction composites.

The result of this study shows that structural concrete can be manufactured with compressive strengths more than 20 MPa by replacing moderately 5–17% of the sand with sawdust or 5–15% of the cement with sawdust ash. By partially substituting sawdust that ranges between 10 and 30% of sand used in the production of blocks and bricks, sawdust blocks and bricks having compressive strengths greater than 3 MPa can be created. According to the findings of this study, sawdust has the potential to make construction composites that are strong, absorb water, and have an elastic modulus that meet international standards. The study concludes that sawdust composites are intriguing due to having hushed heat conductivity, a prominent sound absorption, as well as efficient sound wadding. From the findings, it is demonstrated that an increase in the utilization of sawdust for construction purposes will reduce the possibility of sawdust as a pollution to the environment, and will also ease the costs of disposal.

3. CONCLUSION

The experimental evaluation of concrete strength with the combination of partial replacement of cement by sawdust ash and the addition of polypropylene fiber and steel fiber presents promising opportunities for enhancing the performance and sustainability of concrete. However, further research and development are needed to address optimization challenges and provide comprehensive guidelines for practical implementation in construction projects.

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