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Partially Replacement of Cement with GGBS using Polypropylene Fibre

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A B S T R A C T

The construction industry is increasingly adopting sustainable and cost-effective materials to address environmental concerns and enhance concrete performance. This study investigates the partial replacement of cement with Ground Granulated Blast Furnace Slag (GGBFS) and the incorporation of steel fibers and polypropylene fibers in concrete. GGBFS, a byproduct of steel manufacturing, serves as a sustainable alternative to traditional cement, reducing the carbon footprint and enhancing durability properties. The inclusion of steel and polypropylene fibers improves concrete's tensile strength, impact resistance, and crack control. In this research, cement was replaced with GGBFS at varying proportions (e.g., 20%, 30%, and 40%), while the fiber content was optimized for a hybrid mix of steel and polypropylene fibers. Tests were conducted to evaluate the mechanical properties of the modified concrete, including compressive strength, split tensile strength, and flexural strength. Durability tests, such as water absorption, chloride ion penetration, and resistance to sulfate attack, were also performed to assess the concrete's long-term performance. The results demonstrated that replacing cement with GGBFS enhanced the concrete's workability and durability, with optimal performance observed at 30% replacement. The hybrid fiber mix significantly improved flexural and tensile strength, mitigating cracking under load. This study concludes that the combined use of GGBFS, steel fibers, and polypropylene fibers offers a sustainable, high-performance concrete mix suitable for modern construction applications, including pavements, industrial floors, and precast elements.

Keywords: GGBFS (Ground Granulated Blast Furnace Slag), Polypropylene Fibres, Sustainable Concrete, Cement Replacement, Hybrid Fibre Reinforced Concrete, Compressive Strength, Durability Enhancement, Flexural Strength, Crack Resistance, Environmental Friendly Construction

1. INTRODUCTION

In the recent years, there is great development in the area of admixtures and now a day, the pozzolanic admixtures like fly ash, micro silica are commonly used to enhance performance characteristics of concrete. It is need of time to design and construct the structures which will have greater durability and strength and which have led to develop concept of high performance concrete. The major intension in developing high performance concrete is to have adequate resistance to aggressive environments and to make the structure impermeable. However, use of pozzolanic admixtures like micro silica adds to the cost of concrete which directly affects the cost of the project. It is need to find out the substitute to micro silica without sacrificing the quality and performance of High performance concrete. One of the better alternatives to Micro silica is GGBS. Civil structures made of steel reinforced concrete normally suffer from corrosion of the steel by the salt, which results in the failure of those structures. Constant maintenance and repairing is needed to enhance the life cycle of those civil structures. There are many ways to minimize the failure of the concrete structures made of steel reinforce concrete. The custom approach is to adhesively bond fibre polymer composites onto the structure. This also helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite. But this method adds another layer, which is prone to degradation. These fibre polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the de-lamination of the composite.

1.1 Need

The rapid growth of the construction industry has led to an increased demand for cement, which in turn contributes to high carbon emissions and environmental degradation. To promote sustainable development and reduce the dependency on traditional cement, there is a strong need to explore eco-friendly alternatives. Ground Granulated Blast Furnace Slag (GGBFS), a byproduct of the steel industry, offers a sustainable option that not only reduces carbon footprint but also enhances the durability of concrete.

Additionally, traditional concrete is known for its brittle nature, with poor tensile strength and a tendency to develop cracks under stress. Incorporating polypropylene fibers helps to improve crack resistance, increase tensile strength, and enhance the overall performance of concrete structures.

1.2. Scope

This project explores the partial replacement of cement with Ground Granulated Blast Furnace Slag (GGBFS), a byproduct of the steel industry, to promote sustainable construction practices. By replacing cement with GGBFS at varying percentages (20%, 30%, 40%), the project aims to reduce carbon emissions and utilize industrial waste effectively. In addition, the inclusion of polypropylene fibers enhances the mechanical properties of concrete, particularly tensile strength, impact resistance, and crack control. The combination of GGBFS and polypropylene fibers helps develop a cost-effective, durable, and eco-friendly concrete mix, suitable for modern construction needs.

The project covers concrete mix design, laboratory testing, and performance evaluation under real-life conditions. It includes testing parameters such as compressive strength, split tensile strength, flexural strength, and various durability aspects like water absorption, sulfate resistance, and chloride penetration. The developed concrete mix can be applied in pavements, industrial floors, precast elements, and other high-load bearing structures, providing a sustainable alternative to conventional concrete. This project supports the construction industry's shift towards green and resilient materials, aligning with global sustainability goals.

2. LITERATURE SURVEY

What is literature survey?

Several researchers have explored the partial replacement of cement with industrial byproducts like Ground Granulated Blast Furnace Slag (GGBFS) to improve the sustainability and durability of concrete. Studies show that GGBFS enhances workability, reduces heat of hydration, and improves resistance to chemical attacks. Research also highlights that replacing 20% to 40% of cement with GGBFS results in concrete with higher durability, lower permeability, and reduced environmental impact due to lower carbon emissions. Such studies emphasize the importance of utilizing industrial waste materials to produce eco-friendly and cost-effective concrete mixes.

Incorporating polypropylene fibers into concrete has also been widely studied for its crack resistance and enhancement of tensile strength. Literature indicates that fibers help control micro-cracks and improve the post-cracking behavior of concrete under stress. Combining GGBFS with polypropylene fibers has been shown to enhance the durability, flexural strength, and impact resistance of concrete. Many researchers conclude that this hybrid approach of using supplementary cementitious materials (SCMs) along with fibers creates a high-performance, sustainable concrete mix, making it ideal for applications like pavements, precast elements, and heavy-duty industrial floors.

3. PROBLEM STATEMENT

The increasing demand for cement in the construction industry has significantly contributed to environmental issues, particularly carbon dioxide emissions from cement manufacturing. This has raised serious concerns about the sustainability of conventional concrete. Additionally, the excessive use of natural resources and the increasing cost of cement have prompted researchers and engineers to find eco-friendly alternatives. One promising solution is the partial replacement of cement with Ground Granulated Blast Furnace Slag (GGBFS), an industrial byproduct generated from steel manufacturing. Using GGBFS not only reduces cement consumption but also helps in utilizing industrial waste, thus addressing both environmental and economic challenges.

Another major limitation of conventional concrete is its brittle nature and low tensile strength, making it prone to cracking and early failure under load. This creates a need for improving concrete's tensile strength, impact resistance, and durability. To address this, the inclusion of polypropylene fibers in concrete can effectively control cracks, improve ductility, and enhance long-term performance. However, the combined impact of GGBFS as a partial cement replacement and polypropylene fibers as reinforcement has not been fully explored for real-life applications. This project aims to develop a high-performance, sustainable concrete mix that balances strength, durability, and environmental benefits for modern construction needs.

4. METHODOLOGY

% of GGBS	28 days compressive strength N/mm2	28 days split tensile strength N/mm2
0%	39.23	3
10%	38.25	3.2
15%	38.25	3.2
20%	38.15	3.3
25%	38.85	3.4
30%	38	3.4

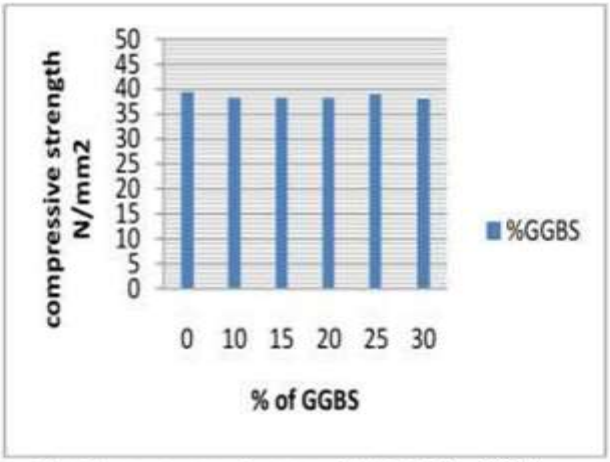
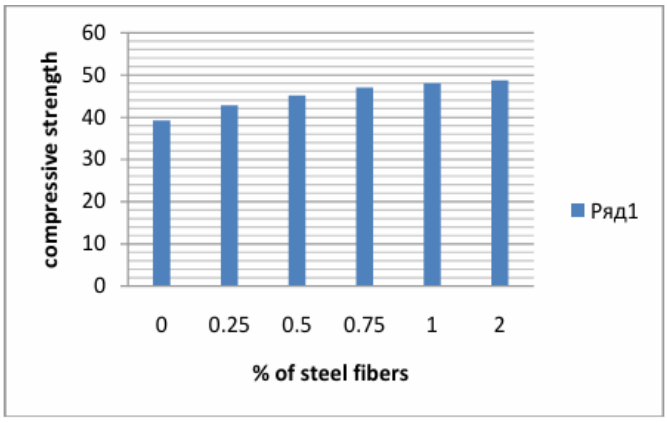
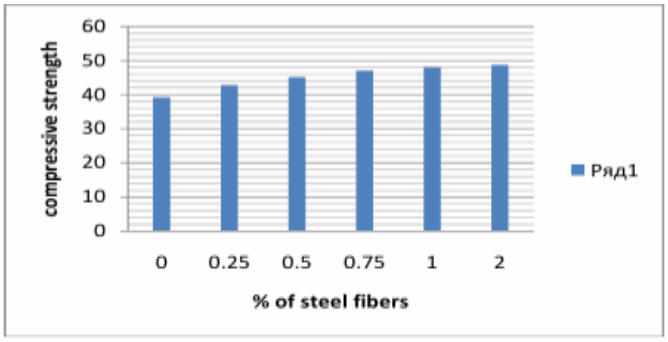


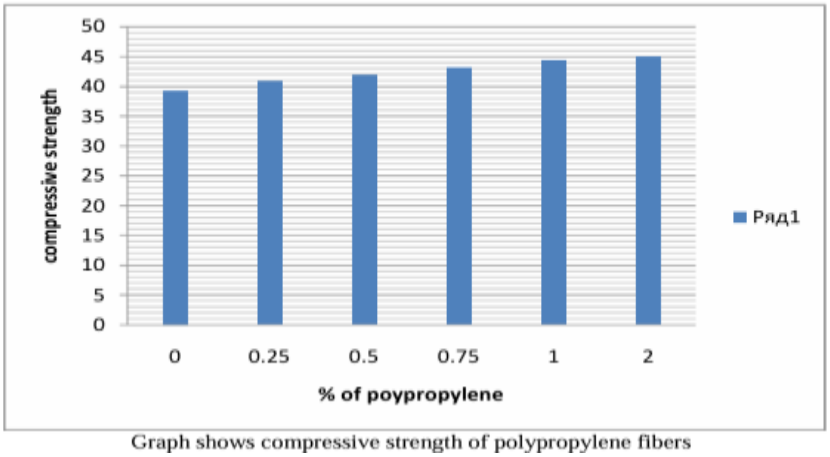
Fig shows compressive strength of GGBS of 28 days



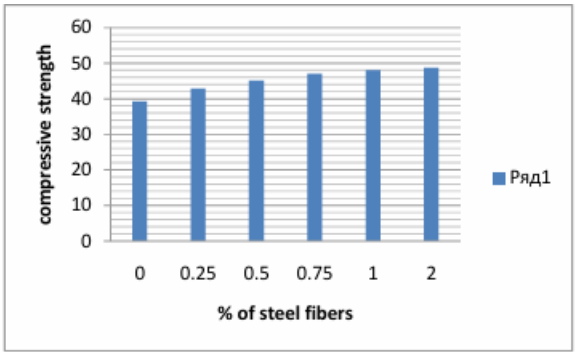


Average compressive and split tensile strength of different % of polypropylene fibers

% of polypropylene fibers	28 days compressive strength	28 days split tensile strength
0%	39.23	3
0.25%	40.85	3.3
0.5%	41.79	3.3
0.75%	42.99	3.4
1.%	44.34	3.45
2%	44.89	3.53



Graph shows compressive strength of polypropylene fibers



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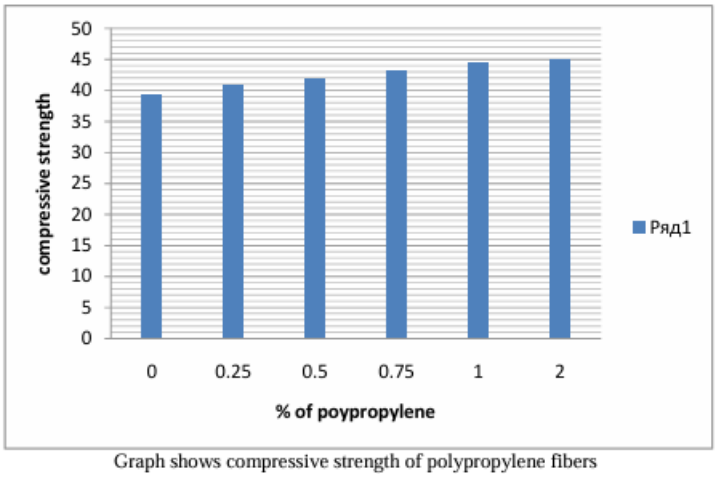

Graph shows compressive strength of polypropylene fibers

5. Conclusion

The normal consistency increases with replacement of cement by pozzolanic materials Such as GGBS. Incase of normal concrete

, part replacement of cement by GGBS satisfactory results are obtained with 20% to 30%. Addition of steel fibers to 25% of GGBS compressive strength increases up to 2% of steel fibers and at 20% of GGBS split tensile strength increases up to 2% addition of steel fibers Addition. Addition of Polypropylene fibers at same percentage of GGBS up to 2% of polypropylene fibers to the concrete compressive strength increases the increase is less when compared to steel fibers. Split tensile strength also increases but increase is less when compared to steel fibers.

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