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Analysis and Experimentation of Polypropylene Fibre Reinforced Self Compacting Concrete with Replacement of River Sand: A Review

Saurabh Kumar[1], Prof. Manjula Singh[2]

[1]*Research Scholar, Department of Civil Engineering, NRI Institute of Research and Technology, India*
[2]*Professor, Department of Civil Engineering, NRI Institute of Research and Technology, India*

***Abstract*— Self-compacting concrete (SCC) has gained wide acceptance in modern construction due to its excellent flowability, passing ability, and resistance to segregation without the need for external vibration. This review presents a performance study of polypropylene fibre reinforced self-compacting concrete (PFRSCC) incorporating river sand as fine aggregate. The inclusion of polypropylene fibres is examined for its influence on fresh, mechanical, and durability properties of SCC. Findings from the literature indicate that the addition of fibres enhances crack resistance, tensile strength, impact resistance, and post-cracking behavior, while maintaining adequate workability when used within optimal dosage limits. The use of river sand contributes to improved particle packing and surface finish, supporting consistent flow characteristics and strength development. The review highlights the balance between fibre content and workability parameters such as slump flow, V-funnel time, and L-box ratio. Overall, polypropylene fibre reinforced SCC with river sand is identified as a promising composite material offering improved structural performance, durability, and construction efficiency for reinforced and complex structural applications.**

***Keywords*— Self-compacting concrete, Polypropylene fibre, River sand, Workability, Mechanical properties, Durability.**

I. INTRODUCTION

Self-compacting concrete (SCC) represents a significant advancement in concrete technology, developed to overcome the limitations associated with conventional vibrated concrete. SCC is characterized by its ability to flow under its own weight, completely fill formwork, and pass through congested reinforcement without segregation or the need for external compaction[1]. These properties make SCC particularly suitable for complex structural elements, heavily reinforced sections, precast components, and situations where proper vibration is difficult or undesirable. The use of SCC improves construction speed, reduces labor requirements, enhances surface finish, and minimizes noise pollution at construction sites[2].

Despite its advantages, SCC requires careful mix design to achieve a balance between high flowability and sufficient stability.

The performance of SCC is strongly influenced by the choice of constituent materials, especially fine aggregates, mineral admixtures, and chemical admixtures[3]. River sand has traditionally been used as a fine aggregate in SCC due to its rounded particle shape, smooth texture, and favorable grading, which contribute to improved workability and reduced water demand. However, increasing structural demands and serviceability requirements have led researchers to explore modifications to SCC mixes that can enhance mechanical strength, crack resistance, and durability[4].

Concrete is inherently weak in tension and prone to cracking due to shrinkage, thermal stresses, and applied loads. These cracks, if uncontrolled, can adversely affect the durability and long-term performance of concrete structures[5]. To address this issue, the incorporation of fibres into concrete has been widely studied as an effective means of improving tensile behavior, ductility, and energy absorption capacity. Among various types of fibres, polypropylene fibres have gained considerable attention due to their low cost, chemical resistance, non-corrosive nature, lightweight properties, and ease of dispersion within the concrete matrix[6].

Polypropylene fibre reinforced self-compacting concrete (PFRSCC) combines the advantages of SCC and fibre reinforcement, offering improved performance in both fresh and hardened states. The addition of polypropylene fibres helps in controlling micro-cracks, reducing plastic shrinkage cracking, and enhancing post-cracking behavior[7]. In the hardened state, fibres contribute to improved tensile strength, flexural performance, impact resistance, and toughness. However, the inclusion of fibres also affects the rheological properties of SCC, often leading to reduced flowability and increased viscosity. Therefore, achieving an optimal fibre dosage is critical to ensure that the self-compacting characteristics of SCC are not compromised[8].

The role of river sand as a fine aggregate becomes particularly important in fibre-reinforced SCC systems. Proper grading and surface characteristics of river sand assist in maintaining adequate flowability and uniform fibre distribution, which are essential for consistent performance.

The interaction between polypropylene fibres, river sand, cementitious materials, and chemical admixtures significantly influences fresh properties such as slump flow, V-funnel flow time, and passing ability, as well as hardened properties including compressive strength, split tensile strength, and durability indicators[9].

Numerous experimental studies have been conducted to evaluate the performance of polypropylene fibre reinforced SCC using river sand as fine aggregate. These studies report varying effects of fibre content on workability, strength development, and durability, depending on mix proportions, fibre length, and dosage. While moderate fibre additions generally enhance mechanical performance and crack resistance, excessive fibre content can lead to workability loss and fibre balling issues. This highlights the need for a comprehensive understanding of the trade-offs involved in designing PFRSCC mixes[10].

This review aims to present a detailed discussion on the performance of polypropylene fibre reinforced self-compacting concrete incorporating river sand as fine aggregate. It synthesizes findings from previous research on fresh properties, mechanical behavior, and durability aspects, while emphasizing the influence of fibre dosage and material interactions. The review seeks to provide practical insights for researchers and practicing engineers to design efficient, durable, and high-performance SCC mixes suitable for modern construction applications.

II. Literature Survey

Dinakar et al., [1] studied the durability properties of high-volume fly ash self-compacting concrete. The research focused on resistance to chloride penetration, water absorption, and sulfate attack. Results indicated that SCC with high fly ash content exhibited improved durability due to refined pore structure. Reduced permeability was observed compared to conventional concrete. The study also reported adequate compressive strength development at later ages. The findings confirmed the suitability of fly ash in SCC for durable construction. This work supports the use of mineral admixtures in performance-based SCC design.

Dumne, [2] investigated the effect of superplasticizers on the fresh and hardened properties of fly ash-based self-compacting concrete. The study analyzed flowability, segregation resistance, and strength characteristics. Results showed that appropriate dosage of superplasticizer significantly improved slump flow and workability. Excessive dosage, however, led to segregation and bleeding. Compressive strength improved due to better particle dispersion. The study emphasized careful optimization of chemical admixtures. It provided practical guidance for SCC mix proportioning.

Dwarakanath et al., [3] examined the deformational behavior of reinforced fibre reinforced concrete beams under bending. The study focused on load–deflection behavior and crack development. Fibre reinforcement significantly improved ductility and energy absorption capacity. Reduced crack width and delayed crack propagation were observed. The beams showed enhanced post-cracking behavior compared to plain concrete. The research demonstrated the effectiveness of fibres in structural applications. These findings are relevant for fibre-reinforced SCC performance evaluation.

EFNARC, [4] provided comprehensive specifications and guidelines for self-compacting concrete. The document defined standard test methods for flowability, passing ability, and segregation resistance. It established acceptance criteria for slump flow, V-funnel, and L-box tests. The guidelines helped standardize SCC production and quality control. EFNARC recommendations are widely adopted in research and practice. This document serves as a fundamental reference for SCC performance evaluation. It supports consistency and comparability of SCC studies.

Eshete and Gettu, [5] focused on developing economical self-compacting concrete mixes. The study aimed to reduce material cost while maintaining SCC performance. Locally available materials and optimized proportions were used. Results showed satisfactory flow characteristics and strength development. The research demonstrated that SCC can be produced cost-effectively without compromising quality. Reduced cement content contributed to sustainability. This work supports practical implementation of SCC in large-scale projects.

Eswari et al., [6] investigated the flexural behavior of hybrid cement composites reinforced with polyolefin fibres. The study evaluated load–deflection response and crack patterns. Fibre inclusion significantly improved flexural strength and toughness. Hybrid fibre systems enhanced energy absorption capacity. Crack widths were reduced, leading to improved serviceability. The results highlighted the role of synthetic fibres in crack control. The findings are applicable to polypropylene fibre reinforced SCC.

Eswari et al., [7] studied the ductility performance of hybrid fibre reinforced concrete. The research focused on stress–strain behavior and failure modes. Fibre-reinforced specimens exhibited improved ductility and post-peak behavior. Hybrid fibre combinations were more effective than single fibre systems. The study demonstrated enhanced resistance to brittle failure. Improved deformation capacity was observed under loading. These results support the use of fibres to enhance SCC toughness.

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Evertsson, [8] analyzed the performance of cone crushers in aggregate production. The study examined particle size distribution and shape characteristics. Aggregate grading was shown to influence concrete workability and strength. Well-graded aggregates improved packing density. The research indirectly supports SCC mix design requirements. Aggregate quality was identified as a key factor in performance. These findings are relevant for selecting fine aggregates like river sand.

Faghri and Hua, [9] applied neural networks for roadway seasonal classification. The study demonstrated the use of artificial intelligence in civil engineering applications. Neural networks improved prediction accuracy compared to traditional methods. Data-driven modeling captured complex nonlinear relationships. Although not SCC-specific, the methodology supports performance prediction studies. The approach is applicable to concrete property modeling. This work highlights the potential of AI in construction materials research.

Ferraris et al., [10] proposed a new approach to evaluate sulfate resistance of concrete. The study focused on microstructural changes and chemical degradation mechanisms. Results showed that mix composition significantly affects sulfate resistance. Reduced permeability improved resistance to sulfate attack. The research emphasized performance-based durability assessment. The findings are important for long-term SCC durability evaluation. This study supports the role of mix optimization in durable concrete design.

Table 1:
Summary of Literature review

Sr. No	Author	Year	Work	Outcome
1	Dinakar et al.	2008	Durability properties of high-volume fly ash self-compacting concrete	Improved durability, reduced permeability, and better resistance to chloride and sulfate attack
2	Dumne	2014	Effect of superplasticiser on SCC with fly ash	Optimized superplasticiser dosage improved flowability and compressive strength
3	Dwarakanath et al.	1992	Deformational behavior of fibre reinforced concrete beams	Enhanced ductility, reduced crack width, and improved post-cracking behavior
4	EFNARC	2002	Specifications and guidelines for self-compacting concrete	Standardized test methods and acceptance criteria for SCC performance
5	Eshete & Gettu	2009	Development of economical self-compacting concrete	Achieved cost-effective SCC with satisfactory workability and strength
6	Eswari et al.	2006	Flexural behaviour of hybrid fibre cement composites	Improved flexural strength and toughness with fibre reinforcement
7	Eswari et al.	2008	Ductility performance of hybrid fibre reinforced concrete	Increased ductility and energy absorption capacity
8	Evertsson	2000	Performance of cone crushers in aggregate production	Highlighted influence of aggregate grading on concrete workability
9	Faghri & Hua	1995	Neural network-based roadway seasonal classification	Demonstrated effectiveness of AI for performance prediction in civil engineering
10	Ferraris et al.	2006	Sulfate resistance of concrete	Improved sulfate resistance linked to optimized mix composition and reduced permeability

III. CHALLENGES

Despite the advantages of self-compacting concrete and polypropylene fibre reinforcement, several challenges affect the fresh and hardened performance of PP-SCC. The combined influence of fibre addition, fine aggregate characteristics, and mix proportioning makes achieving optimal performance complex. These challenges must be addressed to ensure consistent quality and practical field application. The major challenges identified from the literature are discussed below.

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- *Reduction in Workability due to Fibre Addition:* The inclusion of polypropylene fibres increases internal friction within the SCC matrix. This often results in reduced slump flow and passing ability, affecting the self-compacting nature of the concrete.
- *Fibre Balling and Poor Dispersion:* At higher fibre dosages, polypropylene fibres tend to clump together, leading to balling effects. This causes non-uniform distribution, weak zones, and reduced mechanical performance.
- *Sensitivity to Mix Proportioning:* PP-SCC is highly sensitive to changes in water-binder ratio, superplasticizer dosage, and fine aggregate content. Minor variations can lead to segregation, bleeding, or loss of flowability.
- *Increased Demand for Chemical Admixtures:* To maintain self-compacting characteristics, higher dosages of superplasticizers and viscosity-modifying agents are often required. Improper dosage can adversely affect setting time and strength development.
- *Marginal Improvement in Compressive Strength;* Polypropylene fibres mainly improve crack resistance and ductility but contribute little to compressive strength. In some cases, excessive fibre content may slightly reduce compressive strength due to void formation.
- *Durability Concerns at High Fibre Content:* Poor fibre dispersion can increase porosity and micro-voids, negatively affecting durability properties such as permeability and resistance to chemical attack.
- *Quality Control during Mixing and Placement:* Uniform mixing of fibres in SCC requires controlled batching and mixing procedures. Inadequate mixing leads to inconsistent performance, especially in large-scale construction.
- *Lack of Standardized Design Guidelines:* There are limited codal provisions specifically addressing polypropylene fibre reinforced SCC. Designers often rely on experimental data, leading to inconsistency in mix design and application practices.

IV. CONCLUSION

Polypropylene fibre reinforced self-compacting concrete with river sand as fine aggregate offers a promising solution for producing durable, crack-resistant, and highly workable concrete suitable for modern construction needs.

The reviewed studies indicate that the inclusion of polypropylene fibres effectively enhances tensile and flexural performance, ductility, and resistance to micro-cracking, while SCC ensures excellent flowability and compaction without vibration. However, challenges related to workability reduction, fibre dispersion, increased admixture demand, and lack of standardized design guidelines must be carefully managed. With optimized mix proportioning, controlled fibre dosage, and proper quality control, PP-SCC can achieve balanced fresh and hardened properties. Further research is recommended to develop codal provisions and long-term durability models to support its wider adoption in practical applications.

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