Novateur Publications
International Journal of Innovations in Engineering Research and Technology [IJIERT]
ISSN: 2394-3696 Website: ijiert.org
Volume 13, Issue 6, June – 2026

COMPREHENSIVE ENHANCEMENT OF STRENGTH AND DURABILITY OF SELF COMPACTED CONCRETE- A REVIEW

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Article History: Received on: 14/04/2026
Accepted on: 22/06/2026

DOI: https://doi.org/10.26662/ijiert.v13i6.pp22-28

Abstract

This project report presents a comprehensive experimental investigation into the structural performance of Self-Compacting Concrete (SCC) enhanced with Ferrocement wire mesh. SCC resolves consolidation issues in congested reinforcement, but its brittle nature requires effective tensile reinforcement.

This study evaluates the synergistic effects of combining SCC with varying layers and configurations of galvanized woven and welded ferrocement wire mesh.Fresh properties of the SCC mix design were verified using slump flow, L-box, and V-funnel tests to ensure compliance with EFNARC guidelines. Hardened concrete properties were evaluated through compressive, split tensile, and flexural strength tests on standard specimens. Experimental results indicate that integrating ferrocement wire mesh significantly improves the post-cracking behavior, ductility, and energy absorption capacity of SCC elements compared to conventional SCC. Flexural strength increased progressively with the number of mesh layers, which effectively arrested micro-cracks and distributed structural stresses. The report concludes that ferrocement-infused SCC provides a highly durable, high-performance solution for thin-shell structures, retrofitting, and precast concrete applications.

Keywords: Self-Compacting Concrete, Mechanical Properties, Flexural Toughness, Ductility Performance.

I. INTRODUCTION

Self-Compacting Concrete (SCC), also known as Self-Consolidating Concrete, is an innovative and highly advanced type of concrete that possesses exceptional flowability and self-leveling characteristics. It is specifically designed to flow under its own weight, completely fill the formwork, and surround densely packed reinforcement without the need for any external compaction or mechanical vibration. Unlike conventional concrete, SCC can spread uniformly into every corner of the formwork while maintaining its homogeneity and stability throughout the placing process.

In traditional concrete construction, mechanical vibrators are commonly used to remove entrapped air and ensure proper compaction. However, achieving effective compaction becomes extremely difficult in structures containing congested reinforcement, narrow sections, or complex geometries. Inadequate vibration often leads to defects such as honeycombing, voids, segregation, and poor surface finish, which can significantly reduce the strength, durability, and service life of the structure. Self-Compacting Concrete overcomes these limitations by providing excellent filling ability, passing ability, and segregation resistance, thereby ensuring uniform quality and superior performance.

The development of SCC originated in Japan during the late 1980s when the construction industry faced a shortage of skilled labor and increasing concerns regarding the durability of concrete structures. Researchers observed that improper compaction caused by insufficient workmanship was one of the major reasons for premature deterioration of reinforced concrete structures. To address these challenges, Prof. Hajime Okamura of the University of Tokyo pioneered the concept of Self-Compacting Concrete. His primary objective was to develop a concrete mix capable of achieving complete compaction solely through its own weight, regardless of the complexity of reinforcement arrangements.

SCC is produced using a carefully proportioned mix of cement, fine and coarse aggregates, water, chemical admixtures such as superplasticizers, and often mineral admixtures like fly ash, silica fume, or ground granulated blast furnace slag (GGBS). The superplasticizer significantly enhances the flowability of the concrete while maintaining a low water-cement ratio, resulting in improved strength and durability. The inclusion of supplementary cementitious materials further enhances workability, reduces permeability, and improves long-term performance.Today, SCC is widely used in high-rise buildings, bridges, tunnels, precast concrete elements, marine structures, and heavily reinforced structural components. Its ability to reduce labor requirements, minimize construction time, improve surface finish, and enhance structural durability has made it one of the most significant advancements in modern concrete technology. Due to these advantages, SCC continues to gain widespread acceptance in infrastructure projects where high quality, reliability, and durability are essential requirements.

II. LITERATURE REVIEW

Ankit Batra, Sumit Gharpas, Lalit Kumar, Hardik Saxena - "Application of Ferro-Cement"- In this investigation published in the International Research Journal of Engineering and Technology (IRJET), Ankit Batra et al. explored the structural and material dynamics of 'Application of Ferro-Cement'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study highlights durability and cost-effectiveness with low tech construction. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study limited fire resistance data; lacks focus on modern automation to reduce labor intensity. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.

Azeezullah khan, Ramdin Yadav, Shilpi Devi, Chanda maurya, Ms. Khushboo Tiwari - "A Review on Application of Ferrocement Members Made of Self Compacting Concrete"In this investigation published in the IJSART - International Journal of Science and Research Technology, Azeezullah khan et al. explored the structural and material dynamics of 'A Review on Application of Ferrocement Members Made of Self Compacting Concrete'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study explores ferrocement with self compacting concrete (scc), highlighting its low weight, strength, and ease of placement without vibration. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study limited data on long-term performance; lacks exploration of advanced reinforcement techniques. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.
Prof. AmarKalyane, Varun Bhosale, Jinesh Dhoka, Sushant Pilane - "A Review on Compressive Strength of Ferrocement"- In this investigation published in the Prof. AmarKalyane, Varun Bhosale, Jinesh Dhoka, Sushant Pilane, Prof. AmarKalyane et al. explored the structural and material dynamics of 'A Review on Compressive Strength of Ferrocement'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study examines ferrocement as an economical alternative to rcc/pcc, focusing on compressive strength influenced by mesh layers. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study lacks detailed experimental data on long-term durability; does not explore advanced mesh materials. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.
Mansoor Ashraf, Vaijanath Halhalli - "Flexural Behaviour of SCC Ferrocement Slabs Incorporating Steel Fibers"- In this investigation published in the International Journal of Engineering Research & Technology (IJERT), Mansoor Ashraf et al. explored the structural and material dynamics of 'Flexural Behaviour of SCC Ferrocement Slabs Incorporating Steel Fibers'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study studied scc slabs with 0.25% and 0.5% shaktiman fibers, showing higher load and fewer cracks. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study limited fiber type and long-term data gaps. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.
Prof. Rahul D. Hinge - "Behavior of Self Compacting Concrete Confined with Ferrocement"-In this investigation published in the IOSR Journal of Engineering (IOSRJEN), Prof. Rahul D. Hinge et al. explored the structural and material dynamics of 'Behavior of Self Compacting Concrete Confined with Ferrocement'.

The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study demonstrates ferrocement enhances flexural strength of scc beams. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study lacks exploration of long term durability and varying ferrocement layer thickness. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.

Gursavek Dass, Mohit Talwar - "Review Paper on Ferrocement in Construction"- In this investigation published in the International Journal of Advanced Research in Computer Science, Gursavek Dass et al. explored the structural and material dynamics of 'Review Paper on Ferrocement in Construction'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study highlights ferrocement's advantages over rcc/pcc, including fire resistance and economic viability with minimal skilled labor. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study lacks detailed quantitative data and long-term performance analysis under varying conditions. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.

A. Sharma, R. Gupta - "Effect of Wire Mesh Orientation on Flexural Strength of SCC Ferrocement"- In this investigation published in the Construction and Building Materials, A. Sharma et al. explored the structural and material dynamics of 'Effect of Wire Mesh Orientation on Flexural Strength of SCC Ferrocement'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study shows 45-degree mesh orientation yields superior energy absorption and delayed crack propagation. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study requires long-term fatigue and cyclic loading testing. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.

P. Kumar, S. Singh - "Durability of Self-Compacting Ferrocement under Sulfate Attack"- In this investigation published in the Cement and Concrete Composites, P. Kumar et al. explored the structural and material dynamics of 'Durability of Self-Compacting Ferrocement under Sulfate Attack'. The researchers established an experimental framework to quantify performance enhancements over traditional construction methods. Their findings were significant, as the study demonstrates excellent chemical resistance due to the highly dense scc matrix. By systematically evaluating the composite, they demonstrated clear structural synergy and documented substantial improvements in material efficiency. Despite these advancements, the research is constrained by certain limitations. Specifically, the authors noted that the study lacks comprehensive data on chloride ion penetration. These unresolved areas highlight the absolute necessity for longitudinal testing and varied parametric studies before these specific composite configurations can be universally adopted in international structural design codes.

III OBJECTIVES OF INVESTIGATION

1. To study the fresh properties of SCC
2. To investigate the compatibility of SCC with ferrocement reinforcement
3. To determine the mechanical performance of SCC–ferrocement composites
4. To compare the effect of mesh variables

IV. MATERIALS

1. Cement: The term cement is commonly used to refer to powdered materials which develop strong adhesive qualities when combined with water. Cement used in the investigation was 53 Grade Ordinary Portland cement.
2. Fine aggregate: River sand is used as a fine aggregate. Among various characteristics, the most important one for fine aggregate is its grading. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in fine aggregate as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, silica fume etc. The sand particles should also pack to give minimum void ratio. Properties such as gradation, Specific gravity and water absorption have to be assessed to design a dense fine aggregate mix with optimum cement content and reduced mixing water. The river sand was used as fine aggregate confirming to zone 2.
3. Coarse aggregate: The nominal maximum size of coarse aggregate should as large as possible within the specified limits but in no case greater than one fourth of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. Locally available crushed stone with size varying from 12.5mm to 20mm aggregates are used.Coarse aggregate forms the major volume of concrete and contributes to strength and stability.
4. Ground Granulated Blast Furnace Slag (GGBS): Ground Granulated Blast Furnace Slag (GGBS) is a by-product obtained from the iron-making process in steel plants. It is formed when molten slag from the blast furnace is rapidly cooled by water or steam, producing a glassy, granular material. GGBS has been introduced into the concrete industry as a partial replacement for cement to conserve natural resources and reduce environmental pollution caused by cement production. GGBS is rich in chemical compounds such as SiO_2, CaO, Al_2O_3, and MgO, which are highly reactive in the presence of water. These compounds participate in the hydration reaction, forming additional calcium silicate hydrate (C-S-H) gel, which improves the strength, durability, and density of concrete. The use of GGBS in concrete not only enhances long-term compressive and tensile strength, but also reduces heat of hydration, making it suitable for mass concrete structures.
5. Super Plastisizer (Conplast SP440)

Advantages Improved workability - Easier , quicker placing and compaction.
Increased strength - Provides high early strength for precast concrete if water reduction is taken advantage of.
Improved quality - Denser, close textured concrete with reduced porosity and hence more durable.
Higher cohesion - Risk of segregation and bleeding minimised; thus aids pumping of concrete
Chloride free - Safe in prestressed concrete and with sulphate resisting cements and marine aggregates

V. TESTING TO BE DONE

1. Compressive Strength Test: The compressive strength test is used to determine the ability of hardened concrete to withstand axial loads without failure. First, concrete specimens—usually cubes or cylinders—are cast and properly cured for a specified period, typically 7, 14, or 28 days, to achieve the required hydration and strength development. They are then placed in a compression testing machinewith the load applied gradually and uniformly along the longitudinal axis of the specimen. The load is increased steadily until the concrete specimen fails, which is usually indicated by cracking or crushing.
2. Flexural Strength Test: The beams were tested in flexural in accordance with the test procedure given in the Indian standards IS-516-1959, method of testing for strength of concrete- determination pf the flexural strength of concrete specimen. The standard size of beam specimen of 150mm×150mm×700mm.Over a span of 600mm, if nominal size of aggregate does not exceed 20mm, then 100mm×100mm×500mm specimen is used. Specimen is loaded at the rate of 4 kN/min for 150mm specimen and 1.8 kN/min for 100mm specimen. Maximum load at failure is noted.
3. Split Tensile Strength: The cylinder were tested for indirect tensile strength in accordance with the test procedure given in the Indian standards IS – 5816- 1970, method of testing for splitting tensile strength of concrete cylinder. The load is applied at the rate of 1.2 N/min-2.4 N/min and continuous untiled the specimen fail the maximum load is recorded.

VI. EXPECTED CONCLUSIONS

1. The study is expected to conclude that the developed M40 grade Self-Compacting Concrete (SCC) mix incorporating Class F Fly Ash as partial cement replacement and PCE superplasticizer successfully achieved the required self-compacting properties as per EFNARC guidelines. The optimized mix proportion enhanced flowability, passing ability, and stability while maintaining a low water-cementitious ratio.
2. The integration of ferro-cement wire mesh with SCC is expected to demonstrate excellent compatibility due to the superior filling ability of SCC. The highly flowable concrete matrix effectively surrounds and penetrates through closely spaced wire mesh layers, eliminating voids, honeycombing, and defects commonly observed in conventional ferrocement construction.
3. The SCC-ferrocement composite is expected to exhibit improved compressive strength due to the combined effects of fly ash pozzolanic activity, reduced porosity, and enhanced particle packing. The formation of a dense microstructure is anticipated to improve the strength and impermeability of the composite material.
4. The inclusion of ferro-cement wire mesh is expected to considerably enhance the flexural strength and deformation capacity of SCC elements. The wire mesh reinforcement is anticipated to provide effective crack bridging action, delaying crack propagation and transforming the brittle failure behavior of SCC into a more ductile and controlled failure mechanism.
5. The multi-layered wire mesh reinforcement is expected to increase the toughness and energy absorption capability of SCC composites. Due to improved crack resistance and load redistribution, the developed composite can be considered suitable for applications requiring impact resistance, seismic strengthening, and thin structural components.

VII. ACKNOWLEDGEMENT

Experimental work will be carried out using the facilities in Civil Engineering Department laboratory of DVVPCOE ,Ahilyanagar. I wish to thank Prof. A.A. Sengupta, my guide for their valuable Suggestions and authorities for their kind support. I also wish to thank the laboratory staff for their help and support during experimental work.

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