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# A Review on High Performance and Self Compacting Concrete

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**ABSTRACT:** High-performance self-composting concrete (HPSCC) is an innovative material that merges advanced engineering principles with sustainable practices to address the challenges of modern construction. This concrete type incorporates organic waste materials, allowing it to undergo a self-composting process that enhances both its structural properties and environmental performance. HPSCC not only achieves superior mechanical strength and durability—surpassing that of traditional concrete—but also promotes the effective recycling of biowaste, thus reducing overall construction waste. The formulation of HPSCC involves a careful selection of materials, including high-grade aggregates, supplementary cementitious materials, and specific organic additives, which collectively optimize its performance characteristics. Through rigorous testing, HPSCC demonstrates excellent workability, reduced shrinkage, and improved resistance to cracking, making it suitable for various structural applications. In addition to its mechanical advantages, HPSCC contributes to sustainability goals by minimizing carbon emissions associated with concrete production and promoting a circular economy. This paper delves into the development, testing, and practical applications of HPSCC, offering insights into its potential to transform the construction industry. By showcasing the interplay between high performance and ecological responsibility, HPSCC represents a promising step toward greener building practices and enhanced material efficiency. The findings underscore the viability of HPSCC as a transformative solution for the future of sustainable construction.

**KEYWORDS:** Sustainability, Self-composting, Mechanical strength, Biowaste recycling, Circular economy.

## I. INTRODUCTION

High-performance self-compacting concrete (HP-SCC), also known as self-consolidating concrete, is a type of concrete that flows and compacts under its own weight without the need for vibration. It is widely used in various construction projects, including precast industries, high-rise buildings, and structures with congested reinforcement. HP-SCC is characterized by its self-compacting nature, high fluidity, and ability to pass through congested areas while maintaining homogeneity during and after transportation and pouring. It also meets stringent requirements for strength, volume stability, and durability. To produce HP-SCC, a combination of mineral and chemical admixtures, such as superplasticizers, reactive powders, and viscosity improvers, is commonly used. Additionally, the concrete mix often includes reduced amounts of coarse aggregate and increased cement content to enhance homogeneity. The fresh properties of HP-SCC are evaluated using tests like slump flow, J-ring flow, V-funnel, and L-box tests. HP-SCC is a subset of high-performance concrete (HPC), which is designed to meet specific requirements such as low shrinkage, low permeability, high strength, and improved durability, making it a sustainable choice for modern construction.

## II. LITERATURE SURVEY

Ahmad Alyaseen et al. (2023) explores the use of recycled concrete aggregates (RCA) in high-performance self-compacting concrete (HP-SCC) and investigates how various mix design parameters influence its compressive strength (CS). The research focuses on design factors such as water-cement ratio (w/c), water-binder ratio (w/b), superplasticizer use, and RCA percentage, which are key to optimizing the properties of concrete. It also evaluates five soft computing techniques—M5P, random forest (RF), support vector machine (SVM), linear regression (LR), and artificial neural networks (ANNs)—to predict CS. Among these, SVM with the PUK kernel emerged as the most accurate model. The study also includes uncertainty and sensitivity analyses, identifying the most influential parameters

on CS, and aims to reduce the need for laboratory testing, making predictions more cost-effective and efficient for the construction industry. The research provides new empirical models for HP-SCC with RCA and improves understanding of how RCA affects concrete's performance.

Md. Habibur Rahman Sobuz et al. (2022) explores the incorporation of recycled glass waste and Metakaolin (MK) into High-Performance Self-Compacting Concrete (HPSCC) to enhance its fresh, mechanical, and durability properties while reducing environmental impact. Recycled glass aggregates partially replaced natural coarse aggregates (0–40%), while MK partially substituted cement to improve performance. Fresh concrete tests, including slump flow, J-ring, V-funnel, and L-box, demonstrated adequate flowability and passing ability with optimized glass and MK content. Although glass aggregates slightly reduced mechanical performance, MK significantly enhanced strength and ductility. The study highlights the potential of waste glass and MK to improve HPSCC's sustainability, durability, and cost-effectiveness, while non-destructive techniques like the Schmidt rebound hammer provided reliable strength predictions for field applications.

Mohammed A. Al-Osta et al. (2022) discussed on the bonding performance between ultra-high-performance concrete (UHPC) overlays and two types of concrete substrates: concrete screed (CS) and self-compacting concrete (SCC). The study analysed the effects of surface preparation, curing conditions, exposure environments, and test methods on bond strength through experimental investigations. The findings revealed that surface preparation significantly influenced bond strength, with sandblasting yielding the best results, followed by drilled holes. Interestingly, curing conditions, whether water or heat curing, had no notable impact on bond strength. However, exposure to weathering cycles led to a substantial reduction in bond strength. In terms of testing methods, splitting tensile tests were effective in assessing the impacts of cyclic exposure, while bi-surface shear tests highlighted the advantages of drilled-hole surface preparation. Statistical analysis using ANOVA confirmed the critical role of substrate surface preparation and exposure conditions in achieving high bond strength in UHPC-CS and UHPC-SCC composites. The study underscores the importance of proper surface treatment and consideration of environmental factors in designing durable repair systems for reinforced concrete structures.

Ariel Miranda de Souza et al. (2022) study focuses on the environmental impacts of self-compacting concrete (SCC) and explores ways to enhance its eco-efficiency. SCC, while offering high workability and strength, is environmentally harmful due to its high cement and chemical admixture content, contributing significantly to CO<sub>2</sub> emissions. The review emphasizes the potential of incorporating industrial residues like fly ash, rice husk ash, steel slags, and recycled concrete aggregates to reduce the environmental footprint without compromising concrete quality. It also discusses various dosing strategies to optimize these mixes for better eco-performance, using sustainability indicators and eco-efficiency analysis methods. The article highlights that while SCC can be made more eco-friendly, more research is needed to refine these techniques and improve the sustainability of construction materials.

SK Adhikary et al. (2022) The physical and mechanical characteristics of lightweight aggregate are varied according to their type and size. The bulk density of different lightweight aggregate lies in the range of 10 to 1300 kg/m<sup>3</sup> having up to 20% water absorption capacity. The cell size of LWA can lead to variation in strength and bulk density of lightweight aggregate concrete, greater cell size of LWA lead to a decrease in density and strength performance of LWA. The use of lightweight aggregates in lightweight self-compacting concrete can increase the risk of water absorption but with the inclusion of mineral admixtures and polymer coatings, this problem can be eliminated. The surface texture and adhesion properties of lightweight aggregate might differ according to the type of LWA; some LWAs' may have lower adhesion, however, the use of silica fume and polymer coatings can help to mitigate the weaker adhesion and ITZ. The workability of lightweight self-compacting concrete is largely dependent upon the void content and packing density, type, and properties of lightweight aggregate. Porous structured lightweight aggregate absorb some water during the mixing process and lower the workability, use of pre-wetting and pre-treatment with polymers and water glass can positively contribute on workability. Like normal self-compacting concrete, almost similar impact of incorporation of pozzolanic addition, fiber, superplasticizer, and water/binder ratio was noticed in lightweight self-compacting concrete.

C. Thomas et al. (2021) investigates the fatigue behaviour of high-strength plain concrete under cyclic compressive stress at moderate (10 Hz) and high-frequency (resonance ≈100 Hz) loading. Wöhler (S-N) curves were derived for both conditions, revealing distinct behaviours. High-frequency testing showed reduced fatigue life but did not alter the fundamental breaking mechanisms. The study highlights the importance of frequency in designing concrete structures



subjected to dynamic loads, especially for applications like industrial machinery supports. Tests were performed using a load control regime to minimize uncertainties in the stress-strain relationship, as concrete's rigidity limits position-controlled testing. The findings underscore the potential economic and methodological advantages of high-frequency testing while emphasizing its implications for structural design. M. Somasri et al. (2021) discussed the use of Graphene Oxide (GO) in high-strength self-compacting concrete (HSSCC) to improve its rheological and mechanical properties. GO, a nanomaterial with exceptional structural characteristics, enhances cement's microstructure by refining pore structure and forming compact crystalline networks, resulting in significant increases in compressive, tensile, and flexural strengths by 17%, 40%, and 28%, respectively. GO was incorporated in varying dosages (0–0.1% by weight of powder) and evaluated over curing periods of 7, 28, 56, and 90 days, demonstrating improved flow and strength characteristics. While challenges such as limited large-scale production, dispersion difficulties, and minor reductions in workability exist, these can be addressed through optimized mix designs. Additionally, the partial replacement of cement with industrial by-products like GGBS and silica fume enhances sustainability, highlighting GO's potential to advance eco-friendly, high-performance concrete applications.

Manikanta Damma et al. (2021) explores the development of high-performance self-compacting concretes (SCCs) using ternary and quaternary blended cements with fly ash (FA), silica fume (SF), and graphene oxide (GO). The synergistic combination of these materials enhances mechanical and durability properties, such as compressive strength, tensile strength, resistivity, and resistance to chloride penetration. The research highlights how GO improves microstructure and packing density, extending service life in extreme conditions. SCC mixes exhibited excellent workability with no segregation or bleeding, achieving superior slump flow values, particularly in the mix containing FA, SF, and GO, which demonstrates the synergistic effect of combining multiple mineral admixtures.

Nikita Gupta et al. (2021) examines the use of industrial by-products as replacements for fine aggregates in self-compacting concrete (SCC), addressing the dual challenges of depleting natural resources and industrial waste management. By-products such as waste foundry sand, coal bottom ash, waste tire rubber, copper slag, and waste glass are highlighted for their potential to enhance sustainability in SCC production. The review analyzes their physical and chemical properties and their impact on SCC's fresh, mechanical, and durability properties. Incorporating these materials reduces environmental harm, lowers costs, and promotes eco-friendly practices. The study also identifies gaps and provides insights for future research on optimizing SCC mix designs using these by-products.

Olatokunbo M. Ofuyatan et al. (2020) investigates the use of eggshell powder (ESP) and granulated ground blast furnace slag (GGBFS) as partial replacements for cement in self-compacting concrete (SCC). The research focuses on evaluating the fresh and hardened properties, as well as the microstructural characteristics, of SCC with these materials. The study found that 10 wt% partial replacement of cement with ESP or GGBFS provided optimal flowability and workability. SCC with 20 wt% replacements showed the highest compressive and flexural strengths after 28 days of curing. GGBFS SCC exhibited better interfacial interaction and microstructural properties compared to ESP SCC. Additionally, the study compared the effects of ESP and GGBFS on the SCC's fresh properties, using various tests such as slump flow, V-funnel, and L-box. It also assessed the physical properties of aggregates and the final concrete's mechanical performance.

Farhad Aslani et al. (2020) study investigates the fresh and mechanical properties of fibre-reinforced heavyweight self-compacting concrete (FRHWSCC), which combines heavyweight aggregates (magnetite) with steel and polypropylene (PP) fibres. The aim is to improve the mechanical performance of heavyweight concrete (HWC) and self-compacting concrete (SCC). The study explores different fibre types (steel and PP) at varying volume fractions, as well as two levels of heavyweight aggregate content (75% and 100%). Fresh properties were assessed through slump flow and J-Ring tests, while mechanical properties were evaluated through density, compressive, tensile, and flexural strength tests. Results showed that despite the negative impact of fibres and heavyweight aggregates on the workability of SCC, FRHWSCC maintained its self-compacting characteristics. The mechanical properties, such as strength, improved with increasing fibre content, though higher HWA content negatively affected these properties, particularly with aging. Additionally, the inclusion of fibres led to more ductile behaviour, as confirmed by load-deflection curve analysis, compared to plain SCC.

Navdeep Singh et al. (2019) explores the behaviour of High Volume Fly Ash (HVFA) based Self Compacting Concrete (SCC), prepared with Natural Coarse Aggregates (NCA) and Recycled Concrete Aggregates (RCA). It focuses on the effects of HVFA, which includes Fly Ash (FA) and Coal Bottom Ash (CBA), on the fresh, mechanical, and durability

properties of SCC. HVFA-based SCC offers a sustainable solution by utilizing coal ashes and RCA, reducing the environmental impact of waste disposal. The study highlights that while HVFA-based SCC can lower the compressive strength at early ages, it provides satisfactory performance with proper mix design. The combination of HVFA and RCA can enhance sustainability by reducing the need for natural resources. The literature suggests that HVFA-based SCC can be suitable for projects where early compressive strength is not critical, and further research is needed to optimize its properties for broader application.

S. Santo et al. (2019) on the properties of self-compacting concrete (SCC) made with fine and coarse recycled aggregates (RASCC). The increasing demand for sustainable practices in the construction industry has driven interest in using recycled aggregates to reduce the environmental impact of concrete production by minimizing the extraction of natural aggregates and reducing construction and demolition waste. Combining SCC with recycled aggregates offers both environmental and economic advantages, making it a promising material for the construction industry. The review highlights key factors that influence the performance of RASCC, such as the type, shape, and size distribution of the aggregates, which significantly impact mechanical strength, workability, and durability. The study emphasizes the importance of adjusting the water-to-cement ratio (W/C) due to the highwater absorption of recycled aggregates. Superplasticizers can help improve the workability and compaction of RASCC, but their effectiveness diminishes as the amount of recycled aggregate increases. The review also discusses durability issues, noting that recycled aggregate incorporation tends to increase carbonation and chloride penetration, which are linked to the porosity of the recycled aggregates and the mortar adhered to them. The study concludes that while RASCC is a viable and sustainable material for both traditional and complex structural elements, challenges remain regarding strength, durability, and standardization.

Overall, the paper advocates for further research and development to optimize RASCC mixes and improve its adoption in the construction industry, contributing to a more sustainable and circular approach to concrete production.

T.Z.H. Ting et al. (2019) discusses the growing use of lightweight aggregates (LWA) in lightweight self-compacting concrete (LWSCC) as an alternative to traditional concrete. It highlights the advantages of LWSCC, such as reduced weight, lower construction costs, and improved insulation properties, making it suitable for various applications in construction. The paper reviews recent research on LWA, including natural and artificial types, and the challenges in developing LWSCC mix designs. These challenges include the highwater absorption of LWA, which affects workability, and the need for precise mix proportions to achieve desired fresh and hardened properties. The review suggests that LWSCC holds great promise but requires further investigation, particularly in simplifying mix design methods and improving sustainability.

Zohreh Salari et al. (2018) evaluates the mix design and properties of Fiber Reinforced High Strength Self-Compacting Concrete (FRHSSCC), which combines high-strength concrete (HSC), self-compacting concrete (SCC), and fiber reinforcement (FRC). The paper examines the components and proportions used in the mix, including coarse and fine aggregates, fibers, chemical admixtures, and water-to-cement ratios. A key finding is that FRHSSCC can achieve compressive strengths ranging from 50 to 160 MPa, with densities typically between 2300–2500 kg/m<sup>3</sup>. The study also evaluates how different mix designs influence compressive strength, workability, and other mechanical properties. The relationship between factors such as water-to-cement ratio and the amount of fiber added is explored, with observations that higher fiber content can reduce workability but improve strength and ductility. The study presents a comprehensive database of 159 mix designs from the last 12 years, offering insights for future researchers and practitioners in selecting appropriate mix components and achieving desired concrete performance. The first article reviews the mix design of Fiber Reinforced High Strength Self-Compacting Concrete (FRHSSCC), focusing on the components, their proportions, and the compressive strength of FRHSSCC over the past 12 years. It analyzes various materials used in the mix, such as aggregates, admixtures, fibers, and cement, and explores the relationships between compressive strength and factors like water-to-cement ratio, aggregate types, and powder content. The study highlights the variety of mix designs developed to avoid mixing issues.

Qiulei Song et al. (2018) focuses on developing a novel Self-Compacting Ultra-High Performance Fibre Reinforced Concrete (SCUHPFRC) using a blend of silica fume (SF) and metakaolin (MK) as high-active powders. The goal is to improve the properties of Ultra-High Performance Fibre Reinforced Concrete (UHPFRC) by optimizing the use of SF and MK based on particle packing models. The research evaluates the fresh and hardened behaviors of SCUHPFRC and finds that MK is more effective than SF in enhancing hydration kinetics, though excessive MK can lead to shrinkage and viscosity issues. The study aims to explore the hybrid use of SF and MK to overcome challenges related

to UHPFRC production, such as workability and microstructure development, ultimately improving both mechanical properties and durability.

Kursat Esat Alyamac et al. (2017) discusses the Marble sludge, a byproduct of the marble industry, poses significant environmental challenges due to its large volume and disposal issues, with much of it being dumped, leading to pollution and economic loss. Reusing this waste, especially as a fine material in concrete, offers both environmental and economic benefits. This research aims to develop an eco-friendly, efficient self-compacting concrete (SCC) by incorporating high amounts of marble powder. Using Response Surface Methodology (RSM), the study optimizes the mix design by analysing factors like water-to-cement (W/C) and marble powder-to-cement (M/C) ratios. The results show that SCC with W/C ratios below 0.55 and M/C ratios up to 0.6 can be achieved, providing an eco-efficient solution while maintaining the desired properties of fresh and hardened concrete

Belal Alsubari et al. (2016) investigates the use of high-volume treated palm oil fuel ash (T-POFA) as a substitute for ordinary Portland cement (OPC) in self-compacting concrete (SCC) to produce eco-friendly, cost-effective concrete. T-POFA, a byproduct of palm oil mills, was heat-treated to improve its chemical composition and reduce its loss of ignition. Concrete mixtures were prepared with 0%, 50%, 60%, and 70% OPC replacement by mass, maintaining a constant water/binder ratio. The study assessed the fresh properties, compressive strength, drying shrinkage, and acid attack resistance of the SCC. Results showed that high-volume T-POFA enhanced the fresh properties and durability of the concrete, while reducing drying shrinkage. Although early compressive strength was lower, the concrete achieved comparable or higher strength than the control mix at 28 days and later. Cost and carbon dioxide emissions analysis

### III. SUMMARY OF REVIEW

High-Performance and Self Compacting Concrete (HPSCC) properties for structural applications. The experimental program focused on evaluating the fresh-state and hardened-state properties of HPSCC mixtures incorporating varying dosages of flyash and superplasticizer. Results indicated that the addition of flyash significantly enhanced the compressive strength and durability of the HPSCC, while the superplasticizer improved its workability and self-compacting ability. The optimal mixture proportions were identified based on a comprehensive analysis of mechanical properties, including compressive strength, flexural strength, and splitting tensile strength. The findings of this study demonstrate the potential of HPSCC with self-compacting characteristics to offer significant advantages in terms of construction efficiency, structural performance, and durability. Further research is recommended to explore the long-term performance of such concrete in various environmental conditions and to optimize its production and application for specific structural requirements.

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