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An In-Depth Review of Self-Compacting Concrete and its Impact on Construction Practices

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Abstract- Self-Compacting Concrete (SCC) has emerged as a game-changing innovation in the realm of concrete technology, redefining the way we approach construction processes. This review paper offers a comprehensive exploration of SCC, delving into its unique rheological properties that eliminate the need for external compaction, thereby enhancing construction efficiency. Beginning with an overview of the historical development of SCC in the late 20th century, we delve into the constituent materials and intricate mix design methodologies that contribute to its exceptional flow ability and self-leveling characteristics. The paper systematically addresses the fresh and hardened properties of SCC, examining its mechanical performance, durability, and sustainability aspects. Moreover, a critical examination of the challenges associated with SCC and the evolving solutions will be presented. The versatility of SCC extends to a diverse range of applications, and this paper provides insights into its utilization in various construction projects. By synthesizing current research findings and industry advancements, the review aims to consolidate knowledge on SCC, providing a valuable resource for researchers, engineers, and practitioners seeking to understand and harness the full potential of this ground breaking technology in shaping the future of construction practices.

Index Terms- Self compacting concrete, tests

I. INTRODUCTION

Self-Compacting Concrete (SCC) represents a revolutionary advancement in the field of concrete technology, offering a transformative solution to the challenges associated with conventional concrete placement and compaction. Unlike traditional concrete mixes that require manual compaction through vibration or other mechanical means, SCC possesses unique rheological properties that enable it to flow and fill formwork effortlessly without external intervention.

This innovative material has gained widespread recognition and acceptance in the construction industry for its ability to enhance construction efficiency, structural performance, and durability. The development of SCC can be traced back to the late 20th century, with ongoing research and advancements continually expanding its applicability across various construction projects. This review paper aims to provide a comprehensive overview of the key characteristics, constituent materials, mix design methodologies, fresh and hardened properties, and applications of self-compacting concrete, shedding light on its impact on construction practices and the built environment. As we delve into the intricacies of SCC, we will explore the challenges, successes, and future prospects of this cutting-edge technology, highlighting its role in shaping the future of sustainable and efficient construction practices.

II. LITERATURE REVIEW

Cui et al. (2012) [1] conducted a comparative study on lightweight concrete containing different shapes of lightweight aggregates and reported that the shape factor of lightweight aggregates might have a notable impact on the mechanical performance of concrete. An aggregate with a higher Shape Index indicates that it has a more angular shape and so has a greater impact on the mechanical characteristics of concrete.

Karamloo et al. (2016a) [2] studied the impact of maximum lightweight aggregate size on the fresh and mechanical properties of lightweight self-compacting concrete. Study results suggest that as the maximum aggregate size increases, the mechanical performance of the composite increases. While concrete samples prepared with a lower maximum aggregate size show comparatively lower slump flow.

Gesoğlu et al. (2014) [3] reported that incorporation of spherical-shaped LWA in SCC as a replacement of natural aggregates might improve the workability thus attributing to the ease in flow of the lightweight aggregate particles.

Li et al. (2017) [4] reported the importance of packing and mortar film thickness on the workability of shale ceramsite-based LWSCC. Study results reported that a higher amount of cement and fine content increases the film thickness which efficiently improves the workability of LWSCC due to the reduction in friction between aggregates. The study observed almost an increase of 25% in slump flow of LWSCC by increasing mortar film thickness from 1.4 to 2.0 mm. However, above 2.0 mortar film thickness, authors reported a decline in slump flow. While V funnel and T500 time was decreasing with the increase in mortar film thickness of the LWSCC.

Kanadasan and Razak (2014) [5] also reported that the increase in powder or fine aggregate content increases the paste volume of the POC-based LWSCC which significantly improved the workability of concrete. Almost 8% slump flow of LWSCC increased by increasing paste volume from 0.41 to 0.52 m3 /m, while T500 and V funnel time of the composite decreased from 14 to 6 seconds and 5 to 2 seconds, respectively.

Naderi et al. (2018) [6] studied the impact of SF as a partial replacement to cement in scoria-based LWSCC and reported improved flowability, blocking ratio, slump, and V funnel time. The effectiveness of SF was increased by the increased concentration of SF in the concrete mixture. By incorporating 12.5% SF as a replacement to cement, the authors reported an almost 14.5% increase in slump flow.

Ting et al. (2020) [7] studied the impact of fly ash as a partial replacement to cement on the workability of oil palm shell-based LWSCC. Study results indicate that incorporation of FA significantly improved the filling and passing ability of LWSCC. It was observed that replacing 50% of cement by FA increased the slump flow spread from 660 mm to 730 mm and T500 was reduced from 5.04 seconds to 1.82 seconds.

Agwa et al. (2020) [8] reported a comparative study of LWSCC prepared with rice straw ash and cotton stalk ash as a replacement for cement. Study results indicate that relative to the control sample, the workability of LWSCC containing cotton stalk ash and rice straw ash was reduced. The authors observed a nearly 20% and 13% decrease in slump flow, a 133% and 66.6% increase in T500 time, and a 97.2% and 61.6% increase in V funnel flow time by replacing 20% of cement with rice straw ash and cotton stalk ash, respectively. This reduction in workability can be attributed to the high specific surface area of cotton stalk ash and rice straw ash.

Yashar and Behzad (2021) [9] coated scoria and expanded clay with SBR and PVR latex and used it in the LWSCC production. It was reported that the slump of LWSCC improved by 2%–10% due to a reduction in water absorption of aggregates provided with hydrophobic latex coatings.

The improving slump of LWSCC was more significant with higher latex coating layers. Besides polymer membrane layers decreases the frictional forces leading to a decrease in flow time and blocking resistance of LWSCC.

Güneyisi et al. (2016) [10] studied a comparative study of LWSCC prepared with untreated FAA and treated FAA by water glass. It was suggested that LWSCC showed better workability prepared with treated FAA than the untreated FAA aggregates. Due to the hydrophobic water glass coating, the water absorption of FAA, and cohesion forces were reduced leading to an improvement in slump flow and a decrease in flow time and blocking resistance of LWSCC. So, from this literature, it can be concluded that hydrophobic coating on LWA can slightly lower the water demand and improve the workability of concrete.

Altalabani et al. (2020a) [11] studied the impact of micro and macro polypropylene (macro-PP) fibers on the expanded clay-based LWSCC. It was observed that incorporation of both micro and macro PP fibers significantly reduced the slump of LWSCC. By incorporating micro and macro fibers into the LWSCC, the authors reported a nearly 19% and 5.1% decrease in slump flow, respectively. The reduction rate in workability was more significant for micro PP fiber additions than the macro-PP fibers.

Dolatabad et al. (2020) [12] with almost similar mixing composition. These studies reveal that the use of highly porous LWAs such as LECA, pumice, expanded glass, and polystyrene might notably decrease the compressive strength of concrete. A higher decline in compressive strength was observed with a higher concentration of LWA in the concrete mix. Some lightweight aggregates such as rubber and expanded polystyrene have weaker adhesion with cementitious materials.

Li et al. (2017) [13] conducted experimental studies to investigate the importance of packing and mortar film thickness on the strength of LWSCC. It was observed that on 28 days of hydration, a concrete sample with 1.8 mortar film thickness gains maximum strength. By increasing mortar film thickness from 1.4 to 1.8 mm, the authors observed a 21.2% increase in compressive strength. However, the authors also reported that the compressive strength of the concrete samples started to decrease as film thickness increased above 1.8 mm.

Floyd et al. (2015) [14] suggested that the use of a greater amount of cement is required to maintain adequate viscosity for greater workability and higher early strength. However excess amount of cement content might lead to crack and shrinkage and impact the durability characteristics of concrete. From the literature, it can be concluded that the use of a higher amount of fine particles can improve the workability but it can negatively impact the strength gain of LWSCC. Hence selection of an optimum level of fine particles might provide the required workability and strength.

Naderi et al. (2018) [15] used SF in scoria-based LWSCC and reported that the use of silica fume improved the compressive strength of concrete. The addition of 5% SF as a replacement to cement provided optimum compressive strength on 28 and 56 days of hydration. The incorporation of 5% SF resulted in a nearly 6% increase in compressive strength. The improvement in compressive strength was more significant with higher content of cement in the concrete mixture.

Ting et al. (2020) [16] studied the impact of FA on the properties of LWSCC and reported that the addition of FA positively impacted the workability, but declines the compressive strength of concrete. It was also observed that with the rise in FA content the declining rate in compressive strength was more significant. Authors reported an almost 51.8% decline in compressive strength by incorporating 50% FA as a replacement for cement. Basically, the addition of FA in concrete delays the hydration, and concrete achieves lower strength on 28 days.

III. CONCLUSION

The advent of Self-Compacting Concrete (SCC) has marked a transformative epoch in the evolution of concrete technology. From its inception in the late 20th century to its present status as a widely accepted construction material, SCC has demonstrated its ability to redefine conventional construction practices. The inherent flow ability and self-leveling characteristics of SCC have not only streamlined construction processes but have also contributed significantly to improvements in structural performance and durability. The comprehensive examination of SCC presented in this review has highlighted its constituent materials, intricate mix design methodologies, and the fresh and hardened properties that collectively contribute to its success. While SCC has garnered widespread acceptance, challenges such as potential loss of workability over time and concerns regarding cost and material sustainability persist. Ongoing research and development efforts are essential to address these challenges and further optimize the performance and economic feasibility of SCC. As the construction industry increasingly emphasizes sustainable and efficient practices, SCC stands out as a pivotal player in meeting these evolving demands.

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