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Experimental Study on the Performance of Self Compacting Concrete using Stone Dust, Glass Powder & Brick Powder

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Abstract

This study explores the combined effects of replacing natural aggregates with waste brick powder and glass, along with the addition of fiberglass, on the mechanical properties of concrete. The findings reveal that while aggregate replacement alone led to an increase in compressive strength at 7 days, a decline was observed at 28 days. However, the incorporation of fiberglass significantly improved the concrete's performance, with compressive strength increasing by up to 17.05% and flexural strength by up to 37.10% at 28 days. The optimal replacement levels for fine aggregate with brick powder were identified as 25% and 50%, with no substantial differences in compressive strength at 3, 7, and 28 days. This study underscores the potential of utilizing waste brick and glass, combined with fiberglass reinforcement, to produce sustainable concrete with enhanced mechanical properties, contributing to eco-friendly construction practices.

Key Words: Self compacting concrete, Stone Dust, Brick Powder, Glass Powder , Fly Ash, Superplasticizer & VMA Powder

1.INTRODUCTION

Self-compacting concrete (SCC) is a highly advanced type of concrete that flows and settles into place under its own weight without needing external vibration or mechanical compaction. It was developed to address challenges in construction, particularly in areas where traditional concrete compaction methods are difficult or impossible, such as intricate formwork, congested reinforcement, and complex architectural designs.

Unlike conventional concrete, SCC is formulated with a carefully balanced mix of fine aggregates, superplasticizers, and viscosity-modifying admixtures. These components enhance the concrete's fluidity and deformability while preventing segregation and maintaining cohesiveness. This unique combination allows SCC to effortlessly fill tight spaces, corners, and complex geometries while providing a uniform and smooth surface finish.

One of the most significant advantages of SCC is its ability to streamline the construction process. By eliminating the need for mechanical vibration, it reduces labor costs and shortens construction timelines. This also results in lower demand for skilled workers, making it a cost-effective solution for many projects. The absence of vibration equipment contributes to quieter and safer construction environments by reducing noise pollution and minimizing health risks for workers.

Beyond efficiency, SCC offers aesthetic and structural benefits. Its superior flowability leads to better surface finishes and denser, more durable concrete structures. This makes it ideal for applications where visual quality and structural integrity are critical, such as bridges, tunnels, and high-rise buildings.

However, the use of SCC requires meticulous attention to detail in the mix design and quality control. Poorly proportioned mixes can cause issues like segregation, bleeding, and excessive shrinkage, which compromise the concrete's performance. Careful testing and monitoring are essential to ensure the concrete meets the required properties for successful application.

Despite these challenges, SCC continues to gain popularity due to its ability to enhance construction efficiency, quality, and environmental sustainability. When properly designed and applied, it represents a major step forward in modern construction technology.

2. LITERATURE REVIEW

2.1 Stone dust

Sayed Ahmed (2023) This study explores the use of recycled concrete aggregates (RCA) as a replacement for natural coarse aggregate (NCA) in self-compacting concrete (SCC), addressing the depletion of natural aggregates and raw materials. The investigation reveals that 100% replacement of NCA with RCA is feasible with minimal effects on concrete properties, and the optimal mixture consists of 100% RCA, 20% metakaolin, and 22% fly ash, meeting EFNARC specifications. The results show a 8.20% reduction in compressive strength, while ultimate load and flexural stiffness increase by 3.20% and 16.25%, respectively, compared to the control mixture. This research demonstrates the potential of using RCA in SCC, promoting sustainability and reducing the need for natural aggregates in the construction industry.

Abdul Bari J (2023) This study investigates the effects of replacing cement with fly ash on the properties of self-compacting concrete (SCC), a popular material in recent years. The research explores how different fly ash-to-cement ratios impact SCC's characteristics, including compressive strength and long-term durability. The results suggest that replacing cement with fly ash can significantly improve SCC performance while reducing costs and environmental impact. The study finds that using fly ash instead of cement is a viable and eco-friendly strategy to enhance SCC's qualities, making it a valuable resource for building professionals and academics working on sustainable and durable concrete solutions.

Uzma Rashid (2022) Self-Compacting Concrete (SCC) is a revolutionary concrete technology that enables placement without mechanical vibration, ensuring full compaction and strength. Developed in 1988, SCC aims to improve concrete quality and automate construction. Extensive research and practical applications in Japan have followed, primarily by large construction companies.

This study examines the characteristics and mix design specialties that confer SCC's self-compacting capacity. SCC's unique properties and mix design requirements are crucial for achieving its benefits, including improved quality, reduced labor, and increased efficiency. By understanding SCC's characteristics and mix design, this research contributes to the advancement and optimization of this innovative concrete technology.

Rajesh Kumar (2019) This study investigates the development of self-compacting concrete (SCC) with high sand content and varying grades (M20 to M50) using superplasticizer and viscosity modifying agent. The research explores the effects of replacing sand with stone dust (15% to 50%) and cement with fly ash (10% to 40%) on SCC's fresh and mechanical properties. The results show that SCC can be developed at high fine aggregate to total aggregate ratios (S/A) of 0.57, and the optimal mix with 45% sand replacement with stone dust and 20% cement replacement with fly ash achieves significant improvements in fresh properties and a 28.57% increase in compressive strength at 28 days.

MD Ilyas Ahmed (2019) Self-Compacting Concrete (SCC) has revolutionized concrete research since its development in 1986 at the University of Tokyo, Japan. SCC's highly flowable and non-segregating properties enable it to fill formwork and encapsulate reinforcement without mechanical vibration. Recent advances in concrete technology have focused on economical strength improvement using locally available materials. This study investigates the use of quarry dust as a substitute for natural sand and fly ash as a substitute for filler material in SCC.

The results show that partially replacing sand with quarry dust increases compressive strength, with optimal replacement at 40%. Additionally, adding fly ash to the total powder content enhances strength, with optimal addition at 30%. Simultaneous implementation of both substitutes yields further improvements. This research contributes to the optimization of SCC mix design using locally available materials, reducing costs and environmental impact.

Nitesh Ashok Bhange (2018) Self-Compacting Concrete (SCC) is a revolutionary technology gaining popularity globally due to its exceptional properties. The production of SCC requires well-organized equipment and skilled workmanship, emphasizing the importance of proper proportioning, curing, mineral admixtures, and aggregate mixing ratios. These factors significantly influence the mechanical and fresh properties of SCC, making them crucial for achieving high-performance concrete.

Research has focused on enhancing SCC's reliability, quality, and performance, leveraging its non-segregating and flowable nature. Laboratory investigations have explored the effects of fly ash, silica fumes, and stone dust on SCC's compressive strength, revealing significant improvements. The addition of these materials offers numerous advantages, including enhanced compressive strength, making SCC a promising technology for modern construction applications.

2.2 Glass powder

B. Diwakar Rao (2022) The study titled "Experimental Investigation on Self Compacting Concrete Using Glass Powder" focuses on the use of glass powder (GP) as a partial cement replacement in self-compacting concrete (SCC). SCC is a concrete that flows under its own weight, eliminating the need for vibration during placement. Increasingly, industrial by-products like glass powder are being used in SCC to enhance sustainability. Glass powder, rich in silica, has shown potential as a cement replacement due to its chemical reactivity, contributing to environmental sustainability in concrete production. However, its inclusion affects both the fresh and hardened properties of SCC. The flowability and passing ability of SCC are reduced as GP content increases, requiring higher water-to-powder ratios. In terms of mechanical properties, increasing GP leads to reductions in compressive and flexural strengths. Despite these limitations, GP's potential as a sustainable material makes it viable for certain construction applications. The research highlights the trade-off between sustainability and performance in SCC when incorporating glass powder, contributing to advancements in eco-friendly construction materials.

Wisnu Ari Prasetyo (2021) The study on the utilization of glass waste powder as a partial cement substitute in self-compacting concrete (SCC) investigates its potential to improve both tensile strength and porosity in concrete. Glass waste powder shares chemical similarities with cement, specifically in its silica content, making it a viable material for sustainable construction. The research evaluates different percentages of glass waste powder (5%, 10%, 15%, 20%, 25%, and 30%) in SCC and measures their impact after 28 days. Quantitative methods were employed to assess the tensile strength and porosity of the concrete samples. Cylindrical samples of 150 mm in diameter and 300 mm in height were used for both tests, with four samples per variation. The results indicated a significant influence of glass waste powder on both tensile strength and porosity. The optimal tensile strength was achieved with a 5.5% addition of glass powder, yielding a maximum tensile strength of 3.422 MPa. For porosity, the optimal percentage was 8.583%, with a minimum porosity value of 9.806%.

Athraa younis khudair (2020) Optimization of glass powder content in self compacting concrete as partial replacement of cement". In this study, five mixes were designed with different percentages of grinded glass powder used as cement replacement at 0%, 10%, 30%,40%and 50% by weight. The compressive strength, splitting tensile and flexural strength increased when the partial replacement of cement with glass powder up to 30%andtheydecreased behind this as compared to control mix. From the experimental results, at the level 10% of replacement cement by glass powder gave the maximum values of compressive strength and 28 day splitting tensile strength, however, the higher flexural strength is achieved at a level of 20% at 28 day.

V. Gokulnath (2019) Self-compacting concrete (SCC) is a high-performance concrete that can flow and consolidate without mechanical vibration. This study investigates the effects of adding glass powder to SCC to address issues of provision, affordability, strength, and contamination. The experimental study uses M20 grade SCC specimens with four different proportions of glass powder (0.3%, 0.6%, 0.9%, and 1.2%) and a water-cement ratio of 0.45. Fresh concrete tests (slump cone, L-Box, U-Box, V-Funnel, and J-Ring) and hardened concrete tests (flexural strength and split tensile strength) were conducted on both river sand and manufactured sand. The results show the workability and characteristics of the concrete, indicating that glass powder can improve the properties of SCC. This study contributes to the development of sustainable and high-performance concrete mixtures.

Arjun N. (2017) The construction industry's environmental impact is a significant concern, primarily due to Portland cement production, which emits harmful pollutants. To mitigate this, researchers are exploring alternative materials to replace traditional cement and sand. This study investigates the use of Foundry sand and glass powder as substitutes in Self-Compacting Concrete (SCC). Foundry sand and glass powder have been shown to improve concrete properties while reducing waste and environmental impact. This study replaces cement with glass powder (10-50%) and sand with Foundry sand (10%) in SCC mixtures, using Viscocrete 20 HE as an admixture. The mix design follows EFNARC guidelines, and material testing and strength tests are conducted to evaluate the properties of the resulting SCC. This research contributes to the development of sustainable and environmentally friendly concrete mixtures.

A.Rajathi (2014) Recent research focuses on utilizing industrial wastes to create sustainable concrete. This study investigates the effects of adding glass powder to Self-Compacting Concrete (SCC) mixes. The results show that Glass powder reduces self-compactability, filling ability, and passing ability. Flow value decreases with increasing glass powder content (5-15%).V-funnel time increases, indicating higher viscosity and resistance to flow.L-box value decreases with increasing glass powder content (5-15%).Compressive strength decreases with increasing glass powder content (5-15%), with an average reduction of 6-20%.These findings suggest that while glass powder can be used as a supplementary material in SCC, its addition affects the concrete's workability and strength. Further research is needed to optimize the use of glass powder in concrete production.

2.3 Brick powder

Hasan DİLEK (2023) This study investigates the use of waste glass and brick aggregates in cement mortars, highlighting the importance of experimental research in selecting suitable waste materials for engineering applications. The results show that waste glass performs better under compressive loading with a 14% strength decrease, while waste brick inclusion results in a 30% strength decrease. Flexural strength performance reveals that controlled use of waste brick can provide better results, with a 27% strength decrease compared to 38% for waste glass at 50% replacement.

Gulam Mohiuddin Rather (2019) The construction industry's reliance on natural sand and cement has led to environmental concerns and depletion of resources. Surkhi, a by-product from brick kilns, has been investigated as a potential replacement material. A study examined the physical and chemical properties of Surkhi and its effects on concrete workability and compressive strength when replacing 10%, 15%, 20%, and 25% of sand. The results showed that concrete with Surkhi had lower compressive strength at early stages but improved significantly after 28 days, with 20% substitution being the optimal level for strength gain.

Viviana Letelier (2018) This study examines the effects of using waste brick powder as a cement replacement and recycled coarse aggregates in medium-strength concretes. The results show that replacing up to 15% of cement with waste brick powder and 30% of natural aggregates with recycled aggregates does not significantly compromise the compressive strength, flexural strength, and modulus of elasticity of the concrete. This finding highlights the potential for simultaneous use of both residuals to reduce construction waste and promote sustainable development in the construction industry, with minimal impact on the physical properties of the final material.

T K Lohani (2016) This study explores the development of self-compacting concrete (SCC) by replacing natural fine aggregate (sand) with a mixture of brick kiln dust and marble powder, and adding Super Plasticizer (SP 430) and Viscosity Modifying Admixture (VMA). The experimental work involves substituting natural sand with 0%, 25%, and 50% of the brick kiln dust and marble powder mixture to produce M30 grade concrete, aiming to improve the quality and endurance of concrete while reducing the environmental impact of construction materials.

Er. Ranjodh Singh (2013) Self-Compacting Concrete (SCC) has gained popularity in recent years for its suitability in complex structures and high-rise buildings, requiring high fluidity and cohesiveness. To achieve these properties, fine materials like brick dust and marble powder are being used as substitutes for fine aggregates. This experimental study explores the potential of replacing fine aggregates with brick kiln dust and marble powder, which are otherwise waste materials contributing to land scarcity and environmental pollution. Utilizing these waste materials in concrete production is a significant step towards sustainable infrastructure development.

3. CONCLUSIONS

Stone dust:

The study demonstrates that replacing sand with stone dust in Self-Compacting Concrete (SCC) significantly enhances compressive strength and workability. The optimal replacement ratio of 40% stone dust and 30% fly ash content achieves the highest compressive strength, with a 28.57% increase at 28 days. The addition of stone dust improves fresh properties, workability, and strength increase rate, particularly at 28 days due to pozzolanic action. The results show that using stone dust and fly ash in SCC can produce high-strength concrete, with M20 and M25 grades achieving compressive strengths of 22.3 N/mm^2 and 28.31 N/mm^2, respectively. Overall, incorporating stone dust in SCC offers a promising solution for improving concrete properties while utilizing industrial waste.

Glass powder:

This study explores the use of recycled glass powder in self-compacting concrete (SCC) as a step toward more sustainable construction practices. The addition of glass powder not only enhances the concrete's flow properties, such as slump flow, flow ratio, and V-funnel time, but also improves its mechanical strength.

When cement is partially replaced with up to 30% glass powder, there is a noticeable increase in compressive, tensile, and flexural strength. However, beyond this percentage, the strength begins to decline compared to conventional concrete. Based on 28-day compressive strength tests, a 15% replacement of cement with glass powder is identified as an optimal and reasonable amount for achieving durable and eco-friendly concrete, offering a promising solution for sustainable building materials.

Brick powder:

This study investigated the effects of replacing natural aggregates with waste brick and glass, and adding Fibre Glass to concrete mixes. The results showed that compressive strength increased at 7 days but decreased at 28 days with the replacement of natural aggregates. However, the addition of Fibre Glass significantly improved compressive strength (up to 17.05%) and flexural strength (up to 37.10%) at 28 days. The optimal replacement level of fine aggregate with brick powder was found to be 25% and 50%, with no significant difference in compressive strength at 3, 7, and 28 days. Overall, the study suggests that combining waste brick and glass replacement with Fibre Glass addition can enhance the mechanical properties of concrete, offering a sustainable solution for the construction industry.

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