iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71166

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Performance of Self-Compacting Concrete by Amalgamating Waste Materials Using Absolute Volume Method: A Review

Mr. Yogesh Kalare[1], Mr. Rajesh Parve[2]
[1]Research Scholar, Civil Engineering Department, Kavikulguru Institute of Technology and Science, Ramtek, Maharashtra, India
[2]Assistant Professor, Civil Engineering Department, Kavikulguru Institute of Technology and Science, Ramtek, Maharashtra, India

Abstract: Self-Compacting Concrete (SCC) is a highly flowable, non-segregating concrete that spreads into place and fills formwork without mechanical vibration. In recent years, there has been a significant interest in enhancing the sustainability of SCC by incorporating various industrial and agricultural waste materials. This paper reviews the existing literature on the performance of SCC prepared using waste materials such as fly ash, ground granulated blast furnace slag (GGBS), silica fume, rice husk ash (RHA), marble dust, and recycled aggregates. Special emphasis is placed on the application of the Absolute Volume Method (AVM) in mix design to optimize material proportions. This method ensures accuracy in volume-based mix proportioning, which is essential for maintaining the flowability and strength of SCC. The study identifies gaps in current research and outlines future directions for developing greener SCC mixes.
Keywords: Self-Compacting Concrete (SCC), Absolute Volume Method (AVM), Supplementary Cementitious Materials (SCMs), Sustainable Concrete, Industrial Waste, Agricultural Waste.

I. INTRODUCTION

The increasing demand for high-performance and environmentally sustainable construction materials has prompted researchers and engineers to innovate within the field of concrete technology. Self-Compacting Concrete (SCC) has emerged as a revolutionary material in this context, owing to its ability to flow under its own weight, fill intricate formworks, and encapsulate reinforcements without requiring mechanical vibration. However, conventional SCC production still heavily relies on cement, a material with significant environmental costs, particularly in terms of energy consumption and carbon dioxide emissions. In recent years, the incorporation of industrial and agricultural waste materials into SCC has garnered substantial attention as a strategy to address sustainability goals. Materials such as fly ash, ground granulated blast furnace slag (GGBS), silica fume, rice husk ash (RHA), marble dust, and recycled aggregates are being explored as partial replacements for cement and natural aggregates. When properly selected and proportioned, these waste materials not only reduce the environmental footprint but can also enhance certain fresh and hardened properties of SCC. To achieve optimal performance, the mix design of SCC must be meticulously developed. The Absolute Volume Method (AVM) provides a reliable and rational approach to concrete mix design by accounting for the true volumetric proportions of all components. This review paper aims to investigate the performance of SCC when various waste materials are integrated using the AVM, emphasizing their effect on workability, strength, durability, and overall sustainability. The study also identifies knowledge gaps and future directions for optimizing sustainable SCC using this volume-based mix design approach.

II. LITERATURE REVIEW

Numerous studies have examined the impact of incorporating waste materials into SCC to enhance its performance and reduce environmental degradation. Fly ash, a byproduct of coal combustion, is one of the most extensively used supplementary cementitious materials (SCMs) in SCC, offering improved workability and reduced heat of hydration, although its use can lower early-age strength. Ground Granulated Blast Furnace Slag (GGBS) has been found to contribute to long-term strength and durability due to its latent hydraulic properties. Silica fume, with its ultrafine particle size and high silica content, significantly enhances the mechanical strength and impermeability of SCC, though it often requires the use of superplasticizers to maintain flowability. Rice Husk Ash (RHA), an agricultural waste, has shown pozzolanic behavior and is beneficial in reducing permeability, although excessive amounts may affect workability.

Studies involving marble dust indicate its potential as a fine filler material, improving cohesiveness and surface finish of SCC. Recycled aggregates have also been explored, but their higher porosity and water absorption demand careful mix adjustments. While these studies highlight the potential benefits of using waste materials in SCC, most rely on empirical trial-and-error approaches for mix design, leading to inconsistencies in results. Only a limited number of investigations have employed the Absolute Volume Method, which is critical for achieving consistency, accuracy, and uniformity in SCC performance. Furthermore, many researchers have focused only on individual properties such as strength or flowability, with limited attention to the comprehensive performance of SCC in both fresh and hardened states. This review attempts to bridge that gap by consolidating findings related to multiple properties and analyzing the efficacy of AVM in producing optimized SCC mixes incorporating diverse waste materials.

Ahmed, S. et.al. (2023), [1] This study explores the use of recycled concrete aggregates (RCA) as a sustainable substitute for natural coarse aggregates (NCA) in self-compacting concrete (SCC). Experimental evaluation demonstrated that 100% replacement of NCA with RCA is viable, especially when supplemented with 20% metakaolin and 22% fly ash. Although compressive strength decreased marginally by 8.20%, improvements in ultimate load (3.20%) and flexural stiffness (16.25%) were observed, meeting EFNARC guidelines. The research underlines the environmental benefits of using RCA in SCC applications.

Bari, A. J. et.al. (2023), [2] his investigation assesses the effect of partial cement replacement with fly ash on the performance characteristics of SCC. The study analyzed various fly ash-to-cement ratios and found that optimal proportions significantly improved compressive strength, long-term durability, and workability. The findings suggest that fly ash is an effective eco-friendly binder that reduces cement consumption while enhancing SCC's sustainability and structural integrity.

Rashid, U. et.al. (2022), [3] This research presents a historical and technical overview of SCC, emphasizing its evolution since 1988 and its self-compacting behavior without mechanical vibration. The study discusses the special mix design criteria and rheological properties that enable full compaction. It highlights the role of admixtures, powder content, and aggregate gradation in achieving high workability, reduced labor, and quality improvement in modern construction.

Kumar, R. et.al. (2019), [4] A performance-based investigation on SCC using high sand content across varying concrete grades (M20–M50) was conducted. The study incorporated 15–50% stone dust as fine aggregate and 10–40% fly ash as cement replacement. The optimal mix—45% stone dust and 20% fly ash—resulted in improved fresh properties and a 28.57% increase in compressive strength at 28 days. The findings support the viability of using industrial by-products to improve SCC performance.

Ahmed, M. I. et.al. (2019), [5] The study evaluates the dual substitution of quarry dust for fine aggregate and fly ash for filler in SCC. Results revealed that replacing up to 40% sand with quarry dust enhanced compressive strength, while 30% fly ash addition improved overall performance. The combination of both replacements offered synergistic benefits in strength and workability. The research supports cost-effective SCC mix designs utilizing locally sourced waste materials.

Bhange, N. A. et.al. (2018),[6] This study highlights the influence of mineral admixtures and fine aggregate characteristics on the performance of SCC. Incorporating fly ash, silica fume, and stone dust demonstrated significant improvements in compressive strength and flowability. The findings emphasize the importance of proper proportioning and material selection in producing high-quality SCC for modern construction.

The increasing demand for sustainable construction practices has prompted extensive research into the use of waste materials in concrete to reduce environmental impact and improve material performance. Multiple studies have investigated the replacement of conventional concrete constituents with waste glass powder (WGP), municipal solid waste incineration by-products (MSWI), stone dust, fly ash (FA), and coconut fibers (CFs).

Budharapu Neha Guruswami et.al. (2024), [7] conducted experimental studies on M40 grade concrete incorporating glass powder, MSWI, and stone dust. The optimal mix was identified as MD4, comprising 15% GPW, 15% MSWI, and 10% stone dust. This mix yielded the highest compressive, tensile, and flexural strengths. However, increasing replacement levels reduced workability, as measured by slump and compaction factor tests. Overall, the integration of supplementary cementitious materials (SCMs) promoted both durability and sustainability.

Fadi Althoey et al. (2023), [8] examined the effect of fly ash and waste glass in fiber-reinforced concrete. The M4 mix (WG16–FA20–CFs2.5) delivered the highest compressive strength (48.52 MPa at 90 days), approximately 15.8% higher than the control. The presence of CFs helped mitigate cracking, improving flexural strength. However, increased WG content resulted in greater water absorption and permeability due to the formation of permeable pores. Nonetheless, these characteristics remained within acceptable ranges.

Benyahia Amar et al. (2022), [9] evaluated self-compacting repair mortars (SCRM) with WGP replacing cement up to 30%. The study reported reduced fresh workability with higher WGP content. However, WGP significantly improved compressive strength, water absorption, and adhesion properties over longer curing periods. Particularly, mortars with 10–20% WGP met EN 1504-3 requirements for structural repairs, with a strong linear relationship observed between compressive and flexural strength ($R^2 > 0.9781$).

Rekha Yadav et al. (2021)., [10] explored the effects of partial replacement of cement with 15% glass powder and sand with up to 50% stone dust in M30 concrete. Maximum compressive strength (43.2 MPa) was achieved at 40% stone dust and 12% GPW, showing an 18.3% strength increase at 28 days. Slump values decreased with higher replacements, indicating reduced workability. The combined use of stone dust and glass powder enhanced both strength and cost-efficiency.

Samia Tariq et al. (2020),[11] focused on the durability indicators of self-compacting concrete (SCC) incorporating WGP at varying particle sizes and replacement levels (20–40%). At 20–30% replacement, glass powder improved chloride diffusivity, oxygen permeability, porosity, and electrical resistivity, particularly beyond 90 days. Fine particle sizes of glass were crucial in enhancing durability performance compared to both general-purpose and fly ash-based mixes.

Gokulnath et. al. (2019), [12] studied the use of glass powder in Self-Compacting Concrete (SCC) to enhance sustainability and performance. SCC mixes of M20 grade were prepared with varying glass powder content (0.3% to 1.2%) and tested for fresh and hardened properties. The study concluded that glass powder improved the workability and strength characteristics of SCC.

Bhargava et.al. (2016), [13] explored the use of waste glass powder as a partial replacement for fine aggregate (5%–50%) in conventional concrete. The results showed an improvement in flexural and split tensile strength at 25% replacement. The study emphasized the environmental benefits and potential of glass powder for sustainable construction.

Rajathi et.al. (2014), [14] evaluated the impact of glass powder (5%–15%) on SCC properties. The results indicated a reduction in flowability, filling ability, and compressive strength with increased glass content. Despite this, the study highlighted the potential of using glass powder as a supplementary material, suggesting further optimization is necessary.

Wolde et al. (2023), [15] investigated the use of brick powder (BP) as a sand alternative in SCC, focusing on rheological and mechanical properties. At 5% and 12.5% replacement, SCC met workability standards. Although compressive strength slightly decreased at 5%, tensile strength and durability improved, making BP a viable, sustainable material.

Iqbal et al. (2022), [16] evaluated the effects of replacing cement with brick powder (5–15%) and sand with stone dust (10–20%) in SCC. While workability decreased due to high water absorption, mechanical properties like compressive, tensile, and flexural strengths improved with higher brick powder content, showcasing pozzolanic activity and environmental benefits.

Rather et.al. (2019), [17] studied Surkhi, a brick kiln by-product, as a partial sand replacement (10–25%). Though early strength decreased, 28-day strength improved significantly, with 20% replacement yielding optimal results, highlighting Surkhi's long-term performance potential.

Letelier et.al. (2018), [18] demonstrated that replacing 15% of cement with brick powder and 30% of coarse aggregates with recycled aggregates did not significantly affect concrete's mechanical properties, supporting sustainable practices with minimal performance loss.

Lohani et.al. (2016), [19] explored SCC development using brick kiln dust and marble powder as fine aggregate substitutes (0–50%). The use of SP430 and VMA helped maintain desired flow and strength, promoting environmentally friendly concrete production.

Er. Ranjodh Singh et.al. (2013), [20] 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.

A. *Conclusion of Literature Review*

1) Stone Dust: The incorporation of stone dust as a partial replacement for sand in SCC significantly enhances compressive strength and workability. An optimal replacement level of 40% stone dust combined with 30% fly ash yielded a 28.57% increase in compressive strength at 28 days, owing to pozzolanic activity. M20 and M25 grade SCC achieved strengths of 22.3 N/mm² and 28.31 N/mm², respectively. Thus, stone dust effectively improves the fresh and hardened properties of SCC while promoting the use of industrial by-products.

2) Glass Powder: Glass powder, used as a partial replacement for cement in SCC, improves flow properties (e.g., slump flow, V-funnel) and enhances compressive, tensile, and flexural strength up to a 30% replacement level. However, optimal performance is achieved at 15% replacement, beyond which mechanical properties begin to decline. This suggests glass powder can serve as a sustainable cement substitute, particularly at moderate replacement levels.
3) Brick Powder: Replacing natural aggregates with brick powder and incorporating Fibre Glass has shown a mixed effect on compressive strength. While early-age strength improved, a decrease was observed at 28 days without fibre addition. However, adding Fibre Glass enhanced compressive strength by up to 17.05% and flexural strength by 37.10%. Optimal replacement levels of brick powder at 25–50% demonstrated comparable performance to control mixes, supporting its use as a viable and eco-friendly fine aggregate replacement in concrete.

III. PROPOSED METHODOLOGY

The methodology adopted for this review follows a structured approach comprising several key steps:

1) Identification of Research Scope and Objectives

Define the research questions:

- What are the fresh and hardened properties of SCC when waste materials are incorporated?
- How does the Absolute Volume Method influence the consistency and performance of such mixes?
- Establish boundaries for literature selection focusing on:
- SCC incorporating waste materials like fly ash, GGBS, silica fume, rice husk ash, marble dust, glass powder, and recycled aggregates.
- Studies where AVM is applied for mix design or compared to empirical methods.

2) Literature Search and Data Collection
3) Classification of Waste Materials

Categorize the incorporated waste materials based on origin:
Industrial Waste: Fly ash, GGBS, silica fume, marble dust, stone dust, glass powder.
Agricultural Waste: Rice husk ash (RHA), coconut fibers.
Construction & Demolition Waste: Recycled aggregates, brick powder.
Evaluate the role of each material (binder, filler, aggregate substitute) and its effect on SCC properties.

4) Analysis of Mix Design Methodologies

Study the principles and application of Absolute Volume Method (AVM) in SCC design.
Compare AVM with traditional empirical methods (trial-and-error, volumetric batching).
Evaluate how AVM ensures consistency in workability and strength, especially with variable waste material characteristics.

5) Comparative Assessment of Performance Parameters

Fresh State Properties: Slump flow, T50 flow time, L-box, V-funnel, segregation resistance.

6) Critical Review and Gap Analysis

Identify patterns, trends, and inconsistencies in the findings.

7) Recommendations and Future Scope

Propose a standard guideline or framework for SCC mix design using AVM and waste materials.

IV. CONCLUSION

This review has critically examined the current state of research on the performance of Self-Compacting Concrete (SCC) incorporating various industrial and agricultural waste materials, designed using the Absolute Volume Method (AVM). The integration of waste materials such as fly ash, GGBS, silica fume, rice husk ash, marble dust, and recycled aggregates has demonstrated promising potential in improving the sustainability of SCC while maintaining or enhancing its workability and mechanical properties. The AVM has emerged as a rational and precise approach to SCC mix design, offering improved control over volumetric balance and consistency across different concrete batches.

When combined with waste materials, this method ensures the desired self-compacting characteristics are achieved without compromising structural performance. However, the review also reveals that most studies have been fragmented, with a focus on specific materials or isolated properties, and limited adoption of AVM in practical applications. It is evident that the successful implementation of sustainable SCC depends on a thorough understanding of material behavior, mix optimization, and performance evaluation through standardized protocols. Future research should aim to develop comprehensive mix design frameworks that integrate AVM with multi-waste combinations and predictive modeling tools. Such efforts will not only support greener construction practices but also pave the way for high-performance, cost-effective, and environmentally responsible concrete solutions.

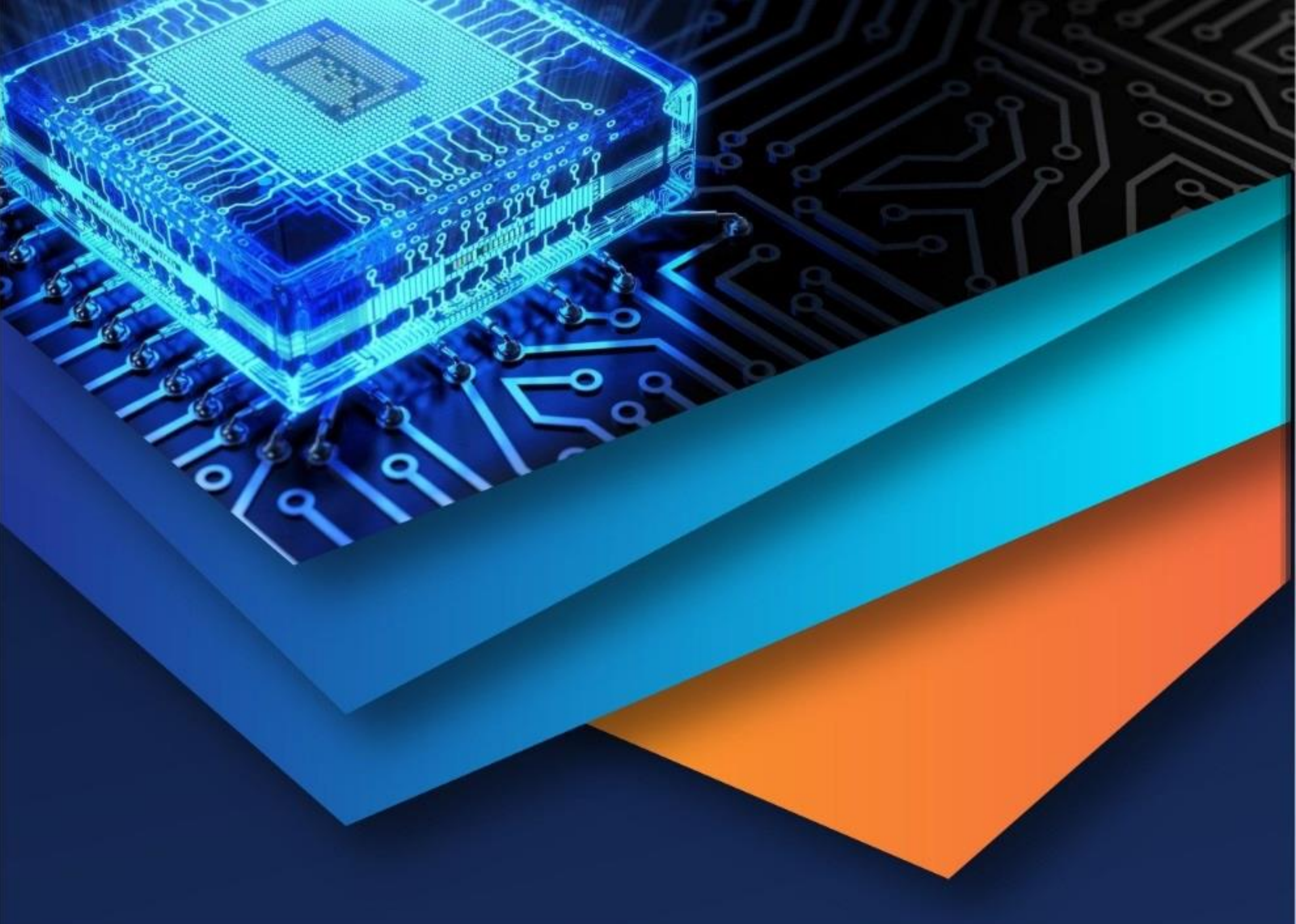
V. ACKNOWLEDGMENT

The authors express their gratitude to the Civil Engineering Department at Kavikulguru Institute of Technology and Science, Ramtek, Maharashtra, for their support and guidance. They extend their sincere appreciation to the faculty members, laboratory staff, and administrative personnel who provided technical assistance and access to necessary resources during the research process. Special thanks are also due to the numerous researchers and professionals whose valuable insights and constructive discussions have significantly contributed to the development of this study.

REFERENCES

[1] Rajathi and G. Portchejian, "Experimental study on self-compacting concrete using glass powder," Int. J. Struct. Civ. Eng. Res., 2014.
[2] Bari and K. Singh, "Experimental Analysis of Self-Compacting Concrete Behavior by Replacing Cement with Fly ash," Eng. Des. Process. Sci., 2023.
[3] N. Arjun, A. Vennila, and V. Sreevidya, "Experimental Study on Self-Compacting Concrete with Foundry Sand and Glass Powder," Int. J. Chemtech Res., 2017.
[4] Y. Khudair and M. K. Mohammed, "Optimization of glass powder content in self-compacting concrete as partial replacement of cement," Inst. Phys. Publ., 2020.
[5] D. Rao and N. V. Babu, "Experimental investigation on self-compacting concrete using glass powder (M25)," Int. J. Res. Trends Innov., 2022.
[6] R. Singh, R. Kaushik, and G. Singh, "Study of Self Compacting Concrete Using Brick Dust and Marble Powder," Int. J. Innov. Eng. Res. Appl., 2013.
[7] G. M. Rather and P. M. Yaseen, "Usage & Impact of Surkhi (Brick Dust) & Fiber Glass in Concrete," Int. J. Innov. Res. Sci. Eng. Technol., 2019.
[8] H. Dilek and P. Akpinar, "A comparative study on the use of waste brick and glass in cement mortars and their effects on strength properties," J. Sustain. Constr. Mater. Technol., 2023.
[9] M. I. Ahmed and S. V. Mohanrao, "High strength self-compacting material for stone dust and fine," Int. J. Mag. Eng. Technol. Manag. Res., 2019.
[10] N. A. Bhange and P. R. Nandagawali, "Experimental analysis of SCC using fly ash, stone dust and silica fumes," Int. J. Innov. Eng. Sci., 2018.
[11] R. Kumar and S. K. Madan, "Experimental study on performance of SCC containing stone dust and material admixture," UK-India Educ. Res. Initiat., 2019.
[12] S. Ahmed and A. El-Zohairy, "Experimental Investigation of Self-Compacting Concrete with Recycled Concrete Aggregate," MDPI, 2023.
[13] T. K. Lohani, S. Pati, and M. Padhi, "Performance Evaluation of Self Compacting Concrete using Brick Dust and Marble Powder," Int. J. Trend Res. Dev., 2016.
[14] U. Rashid and A. Kumar, "Experimental analysis of SCC by replacing sand with stone dust," Int. J. Innov. Res. Eng. Manag., 2022.
[15] V. Gokulnath, B. Ramesh, and S. Suvesha, "Influence on flexural properties of glass powder in self-compacting concrete," Elsevier, 2019.
[16] V. Letelier and J. M. Ortega, "Influence of Waste Brick Powder in the Mechanical Properties of Recycled Aggregate Concrete," MDPI, 2018.
[17] W. A. Prasetyo and E. S. Sunarsih, "Enhancing Tensile Strength and Porosity of Self Compacting Concrete (SCC) with Glass Waste Powder," Inst. Phys. Publ., 2021.
[18] O. Rabiu and O. Damdelen, "Application of Brick Dust and Sawdust in Concrete: A Movement to Sustainability," J. Civ. Eng. Constr., 2023.
[19] Amar, S. Mohamed, and B. Toufik, "Effects of Waste Glass Powder on Properties of Self-Compacting Repair Mortars," Int. J. Eng. Res. Afr.
[20] Nagar and V. P. Bhargava, "Effect of Glass Powder on Various Properties of Concrete," Int. J. Sci. Eng. Technol., vol. 4, no. 4, 2016.
[21] N. Guruswami and Nandini, "Enhancing Durability and Sustainability of Concrete by Experimenting on M40 Grade with Glass Powder (Gp), Municipal Solid Waste (Msw) And Stone Dust," Int. Res. J. Eng. Technol. (IRJET).
[22] F. Althoey et al., "Effect of fly ash and waste glass powder as a fractional substitute on the performance of natural fibers reinforced concrete," Ain Shams Eng. J.
[23] G. M. S. Islam, M. H. Rahman, and N. Kazi, "Waste glass powder as partial replacement of cement for sustainable concrete practice," Int. J. Sustain. Built Environ., vol. 6, pp. 37–44, 2017.
[24] H. A. Rehman, K. G. Sarim, K. Haris, and K. Numan, "Use of Glass Powder as Partial Replacement of Cement in Cement Concrete," Int. J. Eng. Res. Technol. (IJERT).
[25] H. T. Wolde, A. Verma, and H. K. Venkatanarayanan, "Influence of using crushed brick powders as a fine filler substitute in the development of self-compacting concretes," Sādhanā, vol. 48, no. 252, 2023.
[26] M. Naren and C. R. Prasad, "Replacement of Fine Aggregate with Glass Powder in High Performance Concrete," Int. J. Sci. Eng. Technol. Res.
[27] M. B. Vanjare and S. H. Mahure, "Experimental Investigation on Self Compacting Concrete Using Glass Powder," Int. J. Eng. Res. Appl. (IJERA).
[28] M. M. H. Khan et al., "Effect of various powder content on the properties of sustainable self-compacting concrete," Case Stud. Constr. Mater., vol. 19, p. e02274, 2023.
[29] R. Yadav, P. K. Kushwaha, and M. K. Rana, "Effect of Waste Glass Powder and Stone Dust on the Characteristics of Concrete," Int. J. Res. Appl. Sci. Eng. Technol. (IJRASET), 2021.

[30] S. Iqbal et al., "Effect of Brick Powder and Stone Dust on Mechanical Properties of Self-Compacting Concrete," The Sciencetech.
[31] S. Tariq, A. N. Scott, J. R. Mackechnie, and V. Shah, "Durability of High-Volume Glass Powder Self-Compacting Concrete," Univ. Canterbury, 2020.
[32] U. Rashid and A. Kumar, "Experimental Analysis of Self Compacting Concrete by Replacing Sand with Stone Dust," Int. J. Innov. Res. Eng. Manag. (IJIREM).
[33] Y. Aidjouli et al., "Modeling the Properties of Sustainable Self-Compacting Concrete Containing Marble and Glass Powder Wastes Using Response Surface Methodology."
[34] Y. Bouleghebar et al., "The Effect of Brick and Glass Powder on the Mechanical Properties and Porosity of Self-Compacting Mortar," J. Appl. Eng. Sci.



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY