International Journal of Sciences and Innovation Engineering
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
website: www.ijsci.com
Volume 3 Issue 2 , Feb 2026
E-ISSN : 3049-0251
DOI: https://doi.org/10.70849/ijsci03022695730

Utilization of Industrial By-Products in Concrete: A Review on GGBS and Glass Cullet Aggregate

Shivraj Yadav[1], Swati Patel[2], Prof. Kamlesh Kumar Choudhary[3]
[1] UG Student (M. Tech.) Department of Civil Engineering, SIET Engineering College, Jabalpur, MP, India
[2] Assistant Professor, Department of Civil Engineering, SIET Engineering College, Jabalpur, MP, India
[3] HOD & Assistant Professor, Department of Civil Engineering, SIET Engineering College, Jabalpur, MP, India

Article Info

Article History:

Published:10 Feb 2026

Publication Issue:
Volume 3, Issue 2
February-2026

Page Number:
177-183

Corresponding Author:
Prof. Kamlesh Kumar Choudhary

Abstract:
Concrete production requires significant consumption of cement and natural aggregates, leading to depletion of resources and increased CO_2 emissions. The incorporation of industrial by-products and waste materials such as Ground Granulated Blast Furnace Slag (GGBS) and Fine Glass Cullet Aggregate (GCA) offers a sustainable alternative in concrete construction. This review paper presents an overview of previous studies on the use of GGBS as a partial replacement for cement and GCA as a partial replacement for natural fine aggregate. The influence of these materials on workability, compressive strength, tensile strength, flexural strength, and durability characteristics of concrete is critically examined. Findings from the literature indicate that the combined use of GGBS and GCA improves long-term strength, enhances durability, and provides better workability while reducing environmental impact and dependence on natural resources. Optimum replacement levels were found to produce performance comparable to or better than conventional concrete, making this approach suitable for sustainable construction practices.

Keywords: Concrete, Ground Granulated Blast Furnace Slag (GGBS), Fine Glass Cullet Aggregate (GCA), Workability, Durability, Eco-friendly Construction, Waste Utilization

1. Introduction

Natural sand has long been a preferred option for fine aggregate in cement construction. River beds have severe sand depletion, which has multiple negative implications on the ecology. There are alternatives to natural sand being researched. Fine glass cullet aggregate (GCA) are one of the new substitute. Experimental study is used to evaluate the quality, characteristics, and possibilities of fine glass cullet aggregate (GCA) and GGBS as possible substitutes for natural sand in cement concrete. These materials specific gravity, workability, and compressive strength are calculated.

Because of contemporary river erosion and environmental concerns, river sand is in low supply. Therefore, it's imperative to find new materials to replace river sand in order to prevent excessive river erosion and environmental damage. The scarcity or absence of river sand would have an effect on the construction sector. Numerous researchers are finding other materials to replace sand. Two of the primary ingredients are fine glass cullet aggregate (GCA) and ground granulated blast furnace slag (GGBS) . These GGBS and fine glass cullet aggregate (GCA) can be mixed in different ratios to create the necessary concrete mix.

Finding the concrete strength of M30 Grade by partially substituting GGBS and sand is one of the Thesis researches work main goals. To determine the compressive strength, Flexural Strength and Splitting tensile strength of Nominal concrete and Mix multi bended concrete at various levels of Cement and fine aggregate with GGBS and Fine glass cullet aggregate (GCA).

2. Literature Review

Studies on Glass Aggregate and GGBS in Concrete

Manishankar S., et al. (2024) conducted an experimental investigation on the use of waste glass cullet as a partial replacement for fine aggregate in concrete. The study considered replacement levels of 0%, 10%, 20%, and 30% for M20 grade concrete. Results showed that glass cullet up to 30% replacement could be effectively used without adversely affecting performance. The study highlighted the potential of waste glass for resource optimization, waste minimization, and sustainable construction practices.

Abhinav Sharma (2024) studied the effect of glass powder as a partial replacement of cement in recycled concrete. Cement was replaced by glass powder at 5%, 15%, and 25%. The compressive and split tensile strength were found to be maximum at 15% replacement, indicating that glass powder can enhance concrete properties at optimum proportions.

Noor Md. Sadiqul Hasan et al. (2023) investigated the utilization of waste materials in concrete and evaluated strength characteristics at various replacement levels. The study observed that higher replacement percentages led to a reduction in compressive strength, highlighting the need for optimum replacement levels in sustainable concrete development.

Tabasum Jan et al. (2022) examined the effect of partially replacing cement with GGBS and fine aggregate with crushed waste glass. The study reported improved compressive and split tensile strength at optimum replacement levels of around 20% GGBS and 35% glass aggregate.

Jun Zhao (2021) studied the performance of GGBS-based cement concrete under carbonation exposure. Replacement levels of 0%, 30%, 50%, and 70% GGBS were investigated. The study found that GGBS influences carbonation depth and microstructural properties of concrete, highlighting its impact on durability.

B. Rajalakshmi (2020) carried out research on optimization of cement using GGBS in high-performance concrete. Replacement levels ranging from 40% to 70% were tested. Results indicated improved workability and strength, with optimum performance achieved around 45–50% GGBS replacement.

P.K. Prasanna (2019) studied compressive strength of concrete with GGBS and randomly distributed fibers. GGBS replacement levels ranged from 20% to 80%. The results indicated that GGBS can be effectively used up to 60% replacement without significant loss in strength.

S.K. Sirajuddin (2019) investigated concrete properties with GGBS as cement replacement and quarry dust as fine aggregate replacement. The study showed increases of 10–15% in compressive, split tensile, and flexural strength at 40% GGBS and 50% quarry dust replacement.

Pratap Singh (2019) evaluated concrete performance with GGBS and glass fiber addition. Results showed improved tensile strength and moderate improvement in compressive strength at optimum replacement levels.

Anas (2018) reviewed the performance of GGBS as a cement replacement material and concluded that GGBS enhances durability, reduces CO_2 emissions, and improves long-term strength, although early-age strength may reduce.

Shanmuganathan N. (2018) studied the combined effect of GGBS and fly ash in concrete. The results indicated improved compressive strength and durability at suitable replacement levels.

Vaishak K. (2018) evaluated strength and durability properties of concrete using GGBS and fly ash. Maximum strength was achieved with a combination of 20% GGBS and 10% fly ash.

Sunil Bhagwan Yamgar (2018) conducted an experimental study on GGBS concrete and reported increased compressive, tensile, and flexural strength at around 40% cement replacement.

B.K. Varun (2018) studied fresh and hardened properties of concrete with fly ash and GGBS. The results showed improved performance at low to moderate replacement levels.

Chalamcharla Venu Gopal (2017) investigated partial replacement of cement with GGBS and observed increased strength at 40% replacement.

Amunuri Sravan Kumar (2017) analyzed strength development of concrete using GGBS and found that replacement levels of 10–30% provided improved strength and cost benefits.

B. Kaviya (2017) studied M35 concrete with GGBS replacement and observed improved compressive and split tensile strength at around 30% replacement.

Quaid Johar Bhattiwala (2016) examined the effect of GGBS as cement replacement and reported higher strength at 40% replacement.

Jayalakshmi Sasidharan Nair (2016) studied concrete using GGBS and recycled aggregates and found satisfactory strength at 40–50% GGBS replacement.

Dr. G. Sridevi (2016) investigated strength properties of concrete with GGBS replacement and concluded that optimum performance was achieved at about 30% replacement.

3. Gap of Study

Although numerous studies have been carried out on the use of Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement of cement and waste glass as a replacement of fine aggregate, several research gaps still exist in the field of sustainable concrete technology.

- Most previous studies have investigated GGBS and glass aggregate separately; limited research is available on their combined effect in a single concrete mix.
- The interaction between Fine Glass Cullet Aggregate (GCA) and GGBS on fresh properties such as workability, segregation resistance, and finishing characteristics has not been extensively explored.
- Limited experimental data are available on optimum replacement levels when both cement and fine aggregate are simultaneously replaced.
- Studies mainly focus on compressive strength, while other mechanical properties such as split tensile strength, flexural strength, and modulus of elasticity require further investigation.
- Durability aspects such as water absorption, permeability, acid resistance, and long-term performance of GCA–GGBS concrete are not sufficiently documented.
- Microstructural behavior and bonding characteristics between glass particles, GGBS, and cement paste need more detailed study.
- Research on the environmental and economic benefits of using GCA and GGBS together is limited.
- There is a lack of standardized mix design guidelines and practical field applications for combined GCA–GGBS concrete.

4. Materials Used

4.1 Ordinary Portland Cement

Ordinary Portland Cement (OPC 43 Grade) conforming to IS 12269 was used as the primary binding material in the concrete mix. It provides the required strength and durability to the concrete.

4.2 Fine Aggregate

Natural river sand conforming to Grading Zone II of IS 383 was used as fine aggregate. It was clean, well graded, and free from organic impurities.

4.3 Fine Glass Cullet Aggregate (GCA)

Crushed waste glass passing through appropriate sieve sizes was used as a partial replacement for natural fine aggregate. The glass particles were angular in shape and properly cleaned before use to ensure better bonding with the cement matrix.

4.4 Coarse Aggregate

Crushed angular coarse aggregates of 20 mm and 12 mm nominal sizes conforming to IS 383 were used. The aggregates were hard, durable, and free from dust and deleterious materials.

4.5 GGBS (Ground Granulated Blast Furnace Slag)

GGBS was used as a supplementary cementitious material for partial replacement of cement. It improves workability, durability, and long-term strength of concrete.

4.6 Water

Potable water free from harmful salts, oils, acids, and organic matter was used for mixing and curing of concrete as per IS 456 recommendations.

4.7 Chemical Admixture

A superplasticizer conforming to IS 9103 (ECMAS HP 890) was used to enhance workability and reduce water requirement while maintaining the desired strength of concrete.

OPC Cement | **GGBS** | **Fine aggregate** | **Fine glass cullet aggregate (GCA)** | **Crushed stone**

Figure no. 1 ; Multi Blended Concrete

5. Methodology

In this experiment the take a look at of usage of GGBS in concrete in area of cement is performed. first of all, cement and river sand become collected and the take a look at are performed for physical properties like gradation, specific gravity, fineness, and many others.

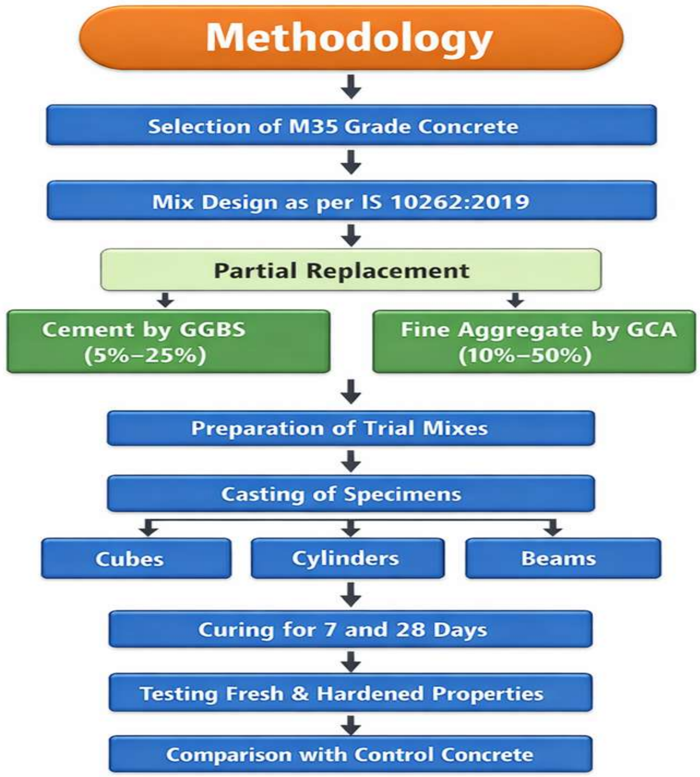

Figure no. 2; Flowchart of Methodology

6. Conclusions

Based on the experimental investigation on concrete incorporating Fine Glass Cullet Aggregate (GCA) as partial replacement of fine aggregate and Ground Granulated Blast Furnace Slag (GGBS) as partial replacement of cement, the following conclusions can be drawn:

The use of GGBS and GCA in concrete improves sustainability by reducing the consumption of natural sand and cement and utilizing industrial and waste materials.

Workability of concrete improved with the addition of GGBS due to its finer particles and better paste formation, while higher percentages of GCA slightly reduced workability because of its angular shape and lower water absorption control.

Compressive strength of concrete increased at optimum replacement levels of GGBS and GCA, particularly at 28 days due to the pozzolanic reaction of GGBS.

Split tensile and flexural strength showed comparable or improved performance at moderate replacement levels, indicating good bonding between glass aggregate and cement matrix.

Excessive replacement of fine aggregate with GCA beyond optimum levels led to a reduction in strength due to weaker interfacial bonding and possible microcracks.

The optimum replacement level was observed around 15–20% GGBS and 20–30% GCA for achieving maximum strength and satisfactory workability.

Durability performance is expected to improve due to reduced permeability and denser microstructure formed by GGBS.

The overall cost of concrete can be reduced by partially replacing cement and natural sand with industrial by-products and waste glass.

The study confirms that GGBS and GCA can be effectively used in structural grade concrete such as M35 without compromising strength requirements.

References

1. Abhinav Sharma (2024) "Effect Of Glass Powder As Partial Replacement Of Cement In Recycled Concrete" 06539 International Journal of Creative Research Thoughts (IJCRT) www.ijcrt.org e875
2. Noor Hasan (2023)"Utilization of Waste Glass Cullet as Partial Substitutions of Coarse Aggregate to Produce Eco-Friendly Concrete: Role of Metakaolin as Cement Replacement" https://www.researchgate.net/publication/372474795
3. Vajrala Kavya Sameera, Lakshmi Keshav (2023) Mechanical And Durability Behaviour Of GGBS, M sand Based Concrete With Varying Percentages Of Two Crystalline Admixtures – An Experimental Study" ITSCMSI-2022 IOP Conf. Series: Earth and Environmental Science 1130 (2023) 012026 IOP Publishing doi:10.1088/1755-1315/1130/1/012026
4. Tabasum Jan (2022) "Replacing Cement Partially by GGBS and Fine aggregate by the crushed waste glass in concrete mix " (IRJET) e-ISSN: 2395-0056 Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072
5. R.Anusuya, D.Chandraleka, S.Sarumathi, G.Karthikeyan (2018) "Experimental Study on Concrete by Replacement of Fine Aggregate with Copper Slag, GGBS and M- Sand" Volume 3, Issue 3, March– 2018 International Journal of Innovative Science and Research Technology ISSN No:-2456-2165IJISRT18MA345 www.ijisrt.com 418
6. P.K. Prasanna (2020) "Compressive Strength Assessment using GGBS and Randomly Distributed Fibers in Concrete" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2020
7. S.k.Sirajuddin (2019) "Experimental Investigation on Properties of Concrete by Partial Replacement of Cement with GGBS and Fine Aggregate with Quarry Dust" International Conference on Advances in Civil Engineering (ICACE-2019) | 21-23 March 2019
8. Anas (2018) "A Review on Ground Granulated Blast-Furnace Slag as a Cement replacing material" International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018
9. Vaishak K (2018) "Study on Strength and Durability Properties of GGBS-Fly Ash based Concrete" IOSR Journal of Engineering (IOSRJEN) ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 08, Issue 6 (June. 2018)
10. Sunil Bhagwan Yamgar (2018) "Study and Analysis of Strength of GGBS Concrete" International Journal of Engineering and Management Research ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962 Volume-8, Issue-6, December 2018
11. B K Varun (2018) "effect of addition of fly ash and GGBS on cement concrete in fresh and hardened state" International Journal of Advance Engineering and Research Development Volume 5, Issue 02, February -2018
12. Chalamcharla Venu Gopal (2017) "Partial Replacement of Cement with GGBS in Concrete" International Journal of Advance Research, Ideas and Innovations in Technology
13. Amunuri Sravan Kumar (2017) "Strength Development of Concrete by Replacing Cement with Ground Granulated Blast Furnace Slag (Ggbs)"
14. Quaid JoharBhattiwala (2016) "Effect of Cementitious Waste Material (GGBS) on concrete as a Replacement in Cement" International journal of science technology & Engineering" ISSN (online): 2349-784X Volume 2,

Issue 11, May 2016

15. Shetty M.S. “Concrete Technology” Chand S. and Co. Ltd., India (2004).
16. IS:456-2000, “Plain and Reinforced Concrete - Code of Practice “Bureau of Indian Standards.
17. IS:456-2000, “Plain and Reinforced Concrete - Code of Practice “Bureau of Indian Standards.
18. IS: 2386-1963 (Part I to Part III), “Indian Standards Method of Test for Aggregate for Concrete”, Bureau of Indian Standards, New Delhi, India
19. 17. IS: 383-1970, “Indian Standard Specification for coarse and fine aggregates from Natural Source for Concrete”, Bureau of Indian Standards, New Delhi, India.
20. IS: 8112-1989, “Specifications for 43-Grade Portland Cement”, Bureau of Indian Standards, New Delhi, India.