ISSN: 2633-4828 Vol. 5 No.4, December, 2023

International Journal of Applied Engineering & Technology

AN EXPERIMENTAL INVESTIGATION ON SUSTAINABLE GREEN CONCRETE

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ABSTRACT

This Project Explores The Mechanical Behavior Of Sustainable Green Concrete Incorporating Ggbs As A Partial Cement Replacement And Conplast Sp430 As A High-Range Water-Reducing Superplasticizer. The Concrete Is Designed For M25 Grade. The Objective Is To Reduce The Environmental Impact Of Cement Production By Partially Replacing Cement With Ggbs Without Compromising The Strength Properties. Three Major Tests Were Conducted: Compressive Strength Test, Split Tensile Strength Test, And Flexural Strength Test.

Keywords: *Green concrete, GGBS, Sustainable construction, M25 grade concrete, Cement replacement, Conplast SP430, Superplasticizer, Mechanical properties, Compressive strength, Split tensile strength, Flexural strength, Environmental impact reduction.*

I. INTRODUCTION

Concrete is the most used construction material globally. However, the production of cement, a key component, is highly energy-intensive and environmentally damaging. Ground granulated blast furnace slag (ggbs), a by-product of the steel industry, is used as a partial replacement to make green concrete. Conplast sp430, a superplasticizer, enhances workability and strength without increasing water content.

Green concrete refers to a type of concrete that is produced with environmentally friendly materials and processes. The goal of green concrete is to reduce the environmental impact associated with traditional concrete production, particularly in terms of carbon emissions, energy consumption, and the depletion of natural resources.

One of the key strategies to achieve this is by replacing conventional cement with sustainable alternatives and enhancing the performance of concrete using additives like **Ground Granulated Blast Furnace Slag (GGBS) and Superplasticizers.** Let's explore how these components contribute to green concrete.

Ground Granulated Blast Furnace Slag (GGBS) in Green Concrete

GGBS is a by – product of the steel manufacturing industry, derived from the rapid cooling of molten iron slag from blast furnaces. When used in concrete, GGBS can replace a portion of the traditional Portland cement. This substitution offers environmental and performance benefits:

1. Reduced Carbon Footprint: The production of Portland cement is a major source of CO2 emissions due to the calcination process that releases CO2. GGBS, on the other hand, is a waste product and requires less energy to process, thus lowering the overall carbon footprint of concrete.

2. Improved Durability: GGBS improves the durability of concrete by enhancing resistance to sulfate attack, chloride-induced corrosion, and alkali-silica reaction, which are common issues in traditional concrete. This leads to longer-lasting structures with reduced need for repairs and maintenance.

3. Reduced Heat of Hydration: The use of GGBS reduces the heat of hydration during the curing process, making it especially useful in mass concrete applications where excessive heat generation could cause cracking.

4. Recycling Industrial Waste: Using GGBS in concrete helps recycle waste material from the steel industry, diverting it from landfills and contributing to a circular economy.

Superplasticizers in Green Concrete

Superplasticizers (also known as high-range water reducers) are chemical admixtures that significantly increase the workability of concrete without the need to add extra water. These additives are crucial in producing high-performance green concrete due to their ability to:

1. Improve Workability: Superplasticizers improve the flowability of concrete, making it easier to mix, transport, and place without compromising the strength. This can reduce the need for mechanical vibration and other energy-consuming processes during construction.

2. Increases Strength: By reducing the water-cement ratio, superplasticizers help increases the density of concrete, leading to higher compressive strength and better overall performance.

3. Sustainability: Using superplasticizers helps optimize the use of cement in the mix. By lowering the amount of water needed while maintaining workability, it ensures that required strength and durability are achieved with a more efficient use of resources, contributing to more sustainable construction practices.

4. Enhance Durability: superplasticizer can also improve the long-term durability of concrete, reducing permeability and enhancing resistance to chemical attacks, which further contributes to the longevity of the structure.

II. APPLICATION AND USES OF GGBS

Ggbs is used to make durable concrete structures in combination with ordinary portland cement and or other pozzolanic materials. Ggbs has been widely used in europe, and increasingly in the united states and in asia (particularly in japan and singapore) for its superiority in concrete durability, the lifespan of buildings from fifty years to a hundred years two major uses of ggbs are in the production of quality-improved slag cement, namely portland blast furnace cement (pbfc) and high-slag blast-furnace cement (hsbfc), with ggbs content ranging typically from 30 to 70% and in the production of ready-mixed or site- batched durable concrete made with ggbs cement sets more slowly than concrete made with ordinary portland cement, depending on the amount of ggbs in the cementation ' s material ,but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required.

III. OBJECTIVES

The main objectives of this study are:

1. To develop green concrete by replacing cement with GGBS.

2. To enhance performance using Conplast SP430.

3. To compare the mechanical properties of green concrete with conventional concrete.

4. To evaluate the sustainability of GGBS-based concrete.

IV. LITERATURE REVIEW

1. Sreedevi Lekshmi, et.al (2022)

The increased demand for cement as a construction material led to its humongous production and hence the emission of carbon dioxide. The geopolymer binder is an alternate binder which make use of aluminosilicate surplus industrial and agricultural waste and hence completely devoid of cement. The current study primarily aims at investigating the durability performance of low calcium fly ash based geopolymer mortar containing clay blends Two types of clay treated with lime, ground granulated blast furnace slag (GGBS) and lime-GGBS combination was used in the study. The optimization tool used was the central composite design in response surface methodology by which a set of trial mixes were obtained. The design trial that exhibited maximum compressive strength and lower water absorption was taken as the optimum mix.

2. V. Jayanthi, et. Al. (2022)

Micronized binomina silica (MBS) and ground granulated blast furnace slag (GGBS) are ag industrial byproducts generated by incineration of sine husk (grinding in jar milli and Islet fur nacres that used produce imam, respectively by incineration of sine husk (grinding in jar milli and Islet fur nacres that used produce imam, respectively. MRS accounts for 20% of the world's total paddy output of 500 million tons. These by-products (MBS and GGBS) have a high concentration of amorphous silica, which is utilized as a mineral additive in concrete. Thise amphioxus silicas in tracts with hydration products, resulting in the formation of additional CSH gel. This improves concrete's strength and durability properties. Therefore, it is proven that inclusimagro industrial try-products in concrete helps to promote attainable and greener develop cat which in turn reduces Raybon footprints and waste that must be disposed of in landfills.

3. Hemlata, et.al (2021)

In the modern age, concrete has become major component in construction field which results in global warming as it contains high amounts of cement. To reduce the carbon footprint and he environment, in our research, cement is eliminated and this type of concrete is called ''Geopolymer concrete''. Binders like Fly-ash, Wollastonite and Ground Granulated Blast Furnace Slag (GGBS) are used and Alkali activators like sodium hydroxide and sodium silicate are used to improve the binding properties of the concrete. Titanium oxide is used to develop self-compacting geo-polymer concrete (SCGPC). At ambient curing conditions, Fresh and hardened properties are tested at 7, 14 and 28 days, SCGPC mixes are developed by adding Titanium oxide to mixes with and without wollastonite at 2%, 4%, 6%. To obtain the optimum results we need to perform some fresh and as well as the Hardened properties. The fresh properties tests include slump flow. Hardened properties of the concrete include the compressive strength and Split Tensile. The optimum test results were obtained at 4% TiO2 with and without wollastonite.

4. Nancy Hammad, at, et. Al (2021)

The fast construction and renovation of roads and bridges and the infrastructures in Egypt and developing countries cause and cement production on a large scale. This huge market demand for precast units and concrete production harms the environment and global warming. Thus, the Ordinary Portland cement (OPS) should reduce by developing new materials such as geopolymer concrete or alkali- activated concrete. This study investigated alkali-activated slag concrete (AAC) performance reinforced with structural polypropylene and steel fibers cured at ambient room temperature. The structural polypropylene and steel fibers were incorporated into the alkali-activated mix by 1.5% and 5% of the total binder weigh, respectively. A wide range of engineering properties was assessed, including compressive strength, split tensile strength and stress-strain behavior, density, water absorption, and porosity.

V. DETAILS OF MATERIALS

Material	Description
Cement	OPC 53 Grade
Fine Aggregate	River sand (Zone II)
Coarse Aggregate	20 mm and 10 mm size
GGBS	Replaces 20%, 30%, 40% of cement
Water	Potable
Superplasticizer	Conplast SP430 (Fosroc)

1). Cement

In this project, Ordinary Portland Cement (OPC) 53 Grade, conforming to IS: 269-1976, is utilized. All specimens are cast using OPC 53 Grade, sourced from a local ready-mix concrete (RMC) plant and manufactured by JSW cements Limited. JSW Cement is preferred due to its widespread availability throughout Bharat. Among the 183-cement manufacture in Bharat, prominent ones include JSW, AAC, Dalmia, JK Cement, Ramco Cement, Heidelberg cement, Birla Corp, Shree Cement. Different types of cement have varying water requirement to produce of standard consistency and affect the concrete's rate of strength development. Therefore, the choice of cement brand and type is crucial for producing high-quality concrete. The compatibility of chemical and mineral admixtures with the cement is essential.

2). Coarse Aggregate

The coarse aggregates (CA) used in this project are locally sourced. These aggregates, derived from basalt rock at a stone crusher, come in various sizes. For this experimental work, the maximum nominal size of the aggregates used was 20 mm, with 10 mm aggregates being the primary ingredients in the concrete mix.

Testing of coarse Aggregate:

1. Specific gravity of coarse aggregate is 2.75
2. Water absorption of coarse aggregate is 1.5%
3. Fineness modulus of coarse aggregate is 3.42

3). Fine Aggregate

The fine aggregates used in this project are locally sourced crushed sand. This sand is washed, effectively removing almost all dust particles. It is notable for not containing any particles that pass through a 75-um sieve, ensuring high purity and suitability for concrete mix. This choice helps maintain the quality and consistency of the concrete.

Testing of Fine Aggregate

1. Specific gravity of Fine aggregate is 2.625
2. Water absorption of Fine aggregate is 2%.
3. Fineness modulus of Fine aggregate is 3.15

4). Ground Granulated Blast Furnace Slag (GGBS)

i. The raw material is a by-product which, if not processed, might end up as landfill, and the manufacturing of GGBS utilizes all of the slag and producing no waste. By utilizing a byproduct, GGBS requires no quarrying of virgin material or mineral extraction.

ii. Replacing the Portland cement by GGBS helps in reducing CO, emissions and in conserving non- renewable resources of lime stone. iii. The carbon footprint can be reduced in direct proportion to reduced clinker content by partial replacement of Portland cement with GGBS. Use of GGBS in concrete is recognized by LEED (Leadership in Energy and Environmental Design) and adds points towards its certification

5). Superplasticizer: Conplast 430 is a type of **superplasticizer** (also known as a high-range water reducer) used in concrete to enhance its workability and performance. Manufactured by **Fosroc Chemicals**, Conplast 430 is specifically designed to improve the flowability of concrete mixes, which helps in achieving a more efficient mix and improved final properties.

V. CASTING

1). Cubes: 150 mm × 150 mm × 150 mm (Compression test)

2). Cylinders: 150 mm diameter × 300 mm height (Tensile test)

3). Beams: 100 mm × 100 mm × 500 mm (Flexural test)

4). Curing period: 7, 14, and 28 days

After preparing the concrete mix, it needs to be filled into moulds for various tests. For the compressive test, the specimens are cubical, measuring 150mm x 150mm x 150mm, and 100mm x 100mm x 500mm for the two-point flexural test. For the splitting tensile strength test, cylindrical specimens of 150mm diameter and 300mm length are specified. When assembling the moulds, the joints between sections must be thinly coated with mould oil. Additionally, a similar coating of mould oil should be applied between the contact surfaces of the bottom of the mould and the base plate to prevent water escape during filling. To prevent concrete adhesion, the interior surfaces of the assembled mould should also be thinly coated with mould oil. The mould itself should ideally be made of metal, such as steel or cast iron, and sturdy enough to prevent distortion.

Figure 1: Casting

VI. TESTINGS

Compressive strength test: Concrete cube specimens (150 mm x 150 mm x 150 mm) for computing compressive strength.

Split Tensile Strength: Concrete Cylinders specimens **(**150 mm diameter × 300 mm height) for computing Tensile strength.

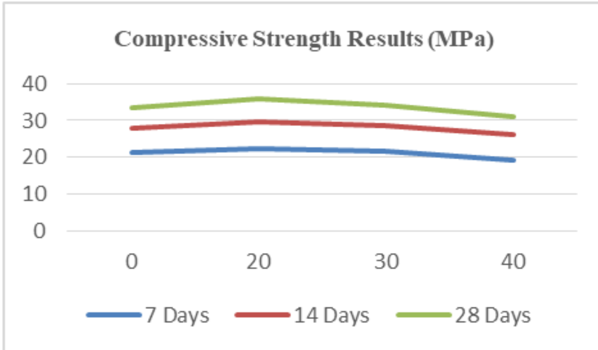
Flexural Strength: Concrete Beams specimens (100 mm × 100 mm × 500 mm) for computing Flexural strength.

VII. RESULTS

1. Compressive Strength Results (MPa)

GGBS %	7 Days	14 Days	28 Days
0% (Control)	21.3	27.8	33.6
20%	22.4	29.6	35.8
30%	21.7	28.5	34.2
40%	19.2	26.1	31.1

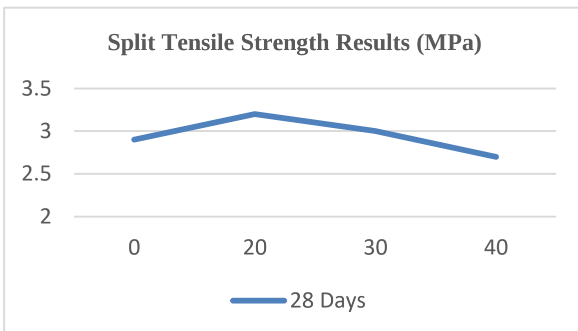
- **Observation: Maximum strength observed at 20% GGBS replacement.**



2. Split Tensile Strength Results (MPa)

GGBS %	28 Days
0% (Control)	2.9
20%	3.2
30%	3.0
40%	2.7

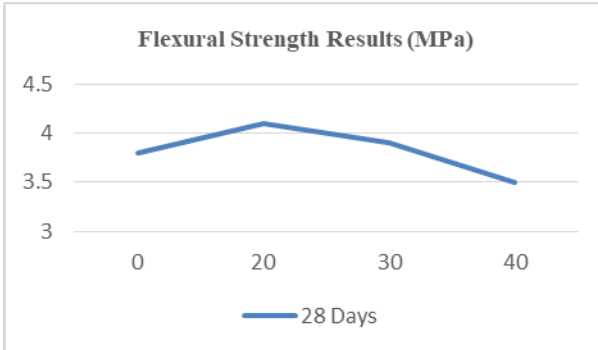
- **Observation: Tensile strength improved with 20–30%** GGBS replacement.



3. Flexural Strength Results (MPa)

GGBS %	28 Days
0% (Control)	3.8
20%	4.1
30%	3.9
40%	3.5

- **Observation: Best flexural performance also observed at 20% GGBS.**



VIII. CONCLUSION

1). GGBS can replace cement up to **20–30%** without compromising mechanical properties.

2). Use of **Conplast SP430** improved workability and strength.

3). 20% GGBS replacement gave **optimal results** in compressive, tensile, and flexural tests.

4). Green concrete is sustainable and cost-effective.

5). Long-term durability studies are recommended.

IX.FUTURE SCOPE

1. Durability tests (sulfate attack, acid resistance).

2. Use of other industrial waste like fly ash, silica fume.

3. Field trials in structural applications.

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