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Exploring the Soundness of M30-Grade Concrete Incorporating GGBS and Groundnut Shell Ash (GSA) as Supplementary Materials

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ABSTRACT: One long-term solution to the problems of excessive concrete usage, negative environmental effect, and poor concrete performance is to augment cement with agro-industrial by-products. Ground Granulated Blast-Furnace Slag (GGBS) and Groundnut Shell Ash (GSA) are partial alternatives to regular Portland cement in M30-grade concrete. This research explores their combined influence, with the goal of creating environmentally friendly building materials and encouraging waste valorisation. It has been demonstrated that when combined with GGBS, Groundnut Shell Ash is a practical, economical, and eco-friendly cementitious material for use in concrete production.

A more realistic approach to managing agricultural waste and reducing Portland cement consumption is presented here. The combined pozzolanic effects of GSA and GGBS lead to a microstructure that is both smooth and less porous. A very pozzolanic material with a high silica concentration, Groundnut Shell Ash (GSA) is made by grinding dried Groundnut Shells into Ash after controlled burning.

In the experimental program, GGBS was maintained at 20% by weight of cement, whereas GSA was gradually adjusted to 0%, 4%, 8%, 12%, 16% and 20%. We prepared a control mix with no GSA and no GGBS, as well as five ternary mixtures with varying amounts of each ingredient: 4% GSA + 20% GGBS, 8% GSA + 20% GGBS, 12% GSA + 20% GGBS, 16% GSA + 20% GGBS and 20% GSA + 20% GGBS. To check how the concrete behaved mechanically strength (compressive, split tensile, and flexural), samples were tested at 7, 14, and 28 days fresh properties, and features were all thoroughly investigated

KEYWORDS: Portland cement, Groundnut Shell Ash (GSA), Ground Granulated Blast-Furnace Slag (GGBS), supplementary materials, M30 concrete, Soundness.

I. INTRODUCTION

1.1 HISTORY BEYOND THE PROXIES USED IN CONCRETE:

Concrete is created from three major parts: water, aggregates like sand, gravel, or crushed stone, and cement. Even though it's the most extensively used construction material in the world, procuring concrete is growing tougher because of many concerns with the ingredients needed to create it.

One huge difficulty is that sand is running out. The need for sand, especially for building, has gone increased a lot. This has led to increasing mining and consumption of sand, generating shortages in many locations. Also, too much sand mining is damaging the ecology. It's altering river flows and destroying ecosystems.

Another problem is the impact to the environment. Making cement consumes a lot of energy and creates a lot of greenhouse gases, which help cause global warming. Also, in regions where there's not enough limestone—a major element in cement—making cement locally is challenging.

The third difficulty is that local sources of rocks and sand, which are crucial for creating concrete, are growing reduced in many regions. Taking these minerals out for too long not only makes them run out faster but also causes additional environmental damage over time.

Concrete is manufactured from cement, which is made from ingredients including limestone, clay, and chalk. When cement is manufactured, a lot of carbon dioxide is emitted into the air, which is detrimental for the environment and humans. Using energy effectively and obtaining carbon credits is vital for improving life for humans. Concrete is utilised in many buildings and constructions because it is sturdy and can tolerate diverse weather and circumstances. When coupled with steel, it can bear huge loads. Most cement used in building is typical Portland cement, which is manufactured from natural ingredients with specified chemical qualities.

Using groundnut shell ash (GNSA) helps minimise environmental pollution. In recent times, people have started using natural elements like pozzolanas instead of cement to build stronger and more lasting concrete. These materials are frequently waste products and can be used to replace cement. Examples include red dirt, paper trash, and industrial wastes. In this work, GNSA is employed as a partial alternative for cement. Groundnut shells are utilised as fuel in food and oil sectors, and the ash left behind can be used as a substitute ingredient for cement. This assists in decreasing waste and utilising the ash more effectively.

Using GNSA in concrete helps minimise prices, reduces pollutants, and saves energy. It has good pozzolanic qualities and includes specific chemical ingredients. As time passes, the pozzolanic activity of GNSA rises. Adding GNSA to concrete helps minimise drying shrinkage and water absorption, but may also make the concrete take longer to cure due to its sluggish response rate. The presence of GNSA can clog the pores in concrete, enhancing its strength and making it more waterproof. The major objective is to develop a technique to lessen environmental harm caused by cement manufacture by employing GNSA.

1.2 ABOUT GROUNDNUT SHELL ASH (GSA)?

Groundnut is a member of the legume family, technically known as *Arachis hypogaea* Linn. It is a sort of plant that grows on its own, is annual and has a delicate, green stem. The full seed of groundnut is known as a pod, and inside it, there are one to five seeds called kermis. These kermises develop underground through a narrow structure called a peg, which finally evolves into a pod. Groundnut has a primary root system with many tiny nodules on the roots and side roots. These nodules contain Rhizobium bacteria, which are useful in nature and assist the plant collect nitrogen from the air. The outer covering of the groundnut is called the shell. The shell takes up roughly 25-35% of the pod, while the seeds make up the rest, around 65-75%.

1.3 WHAT IS GROUND GRANULATED BLAST FURNACE SLAG (GGBS)?

GGBS stands for Ground Granulated Blast-furnace Slag. It is a byproduct created during the steel making process. When molten iron slag from a blast furnace is swiftly cooled with water or steam, it produces tiny which are then crushed into a fine powder. This substance is commonly used as a partial substitute for Portland cement in building concrete.

1.4 MANUFACTURING PROCESS OF GROUNDNUT SHELL INTO ASH:

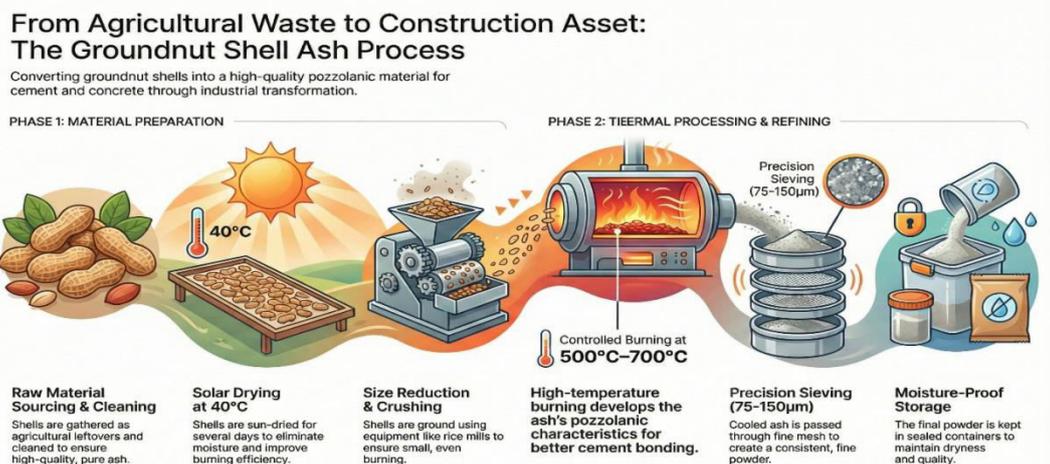


Fig 1: The procedure of manufacturing ash from Groundnut Shell

II. LITERATURE SURVEY

The integration of extra cementitious materials like GGBS, an industrial by-product from iron manufacturing, and GSA, generated from agricultural waste, has been researched to promote concrete sustainability by reducing cement consumption, cutting CO₂ emissions, and reusing waste materials. This study synthesizes major research chronologically, covering mechanical qualities, durability, workability, and appropriate replacement levels. While GGBS is generally utilised at larger percentages (30-60%) for better long-term strength, GSA is normally limited to 10-20% due to its weaker pozzolanic action. Combinations of both show promise for synergistic effects but are underexplored.

1. Mahmoud et al. (2012) evaluated GSA as a partial cement replacement in sandcrete blocks, investigating replacements from 0% to 50%. They discovered that compressive strength peaked at 20% GSA with 3.58 N/mm² at 28 days, declining beyond this because to diminished pozzolanic reactivity. The study underlined GSA's significance in cost-effective, lightweight blocks and waste management in agricultural settings, albeit greater replacements led to unacceptable strength loss.
2. Nwofor and Sule (2012) evaluated GSA in OPC concrete with replacements up to 40%. Compressive strength dropped with increasing GSA but remained viable up to 10%, attaining roughly 70% of control strength at 28 days. They emphasised lower density and GSA's potential for sustainable mass concrete, emphasising environmental benefits from waste reuse, but advised against increased replacements owing to hydration concerns.
3. Rughooputh and Rana (2014) evaluated GGBS replacement in concrete from 0% to 110%, indicating 50% as optimum. This amount enhanced workability, tensile strength (by 17%), flexural strength (by 24%), modulus of elasticity, and decreased drying shrinkage and surface absorption. The tighter microstructure boosted durability, making GGBS suited for structural applications, albeit early-age strength was reduced.
4. Mujedu (2016) studied GSA in concrete, substituting cement from 0% to 15%. Strength was acceptable up to 15% without considerable loss, with GSA functioning as a pozzolan for long-term improvements. Recommended for low-cost housing, the study highlighted environmental advantages in recycling agricultural waste, while workability reduced at greater levels.
5. Krishnan and Nizar (2016) investigated GSA in M20 concrete, finding 2.5% as ideal for compressive strength. Higher levels lowered workability due to GSA's silica content increasing pozzolanic reactions. Suggested for non-structural elements, the research underlined GSA's potential in eco-friendly combinations.
6. Reddy (2017) analysed GSA replacements up to 15% in concrete. At 10%, strength characteristics were maintained efficiently, with minor changes in compressive, flexural, and tensile strengths. The study revealed GSA's feasibility as a cost-reducing pozzolan without major performance sacrifice.
7. Mallikarjuna Prasad P, Vanam Sameer Kumar (2025) The objective is to reduce dependence on Portland cement, and improve the sustainability of concrete. The GGBS & BD both are replaced in place of cement by maintaining GGBS as constant with 15% and BD with ascending follows from 0%, 3%, 6%, 9%, 12% & 15% an expansion of plasticizer with a steady rate 1% within the volume of concrete in M35 Solid. Combining 9% BD with 15% GGBS yields the optimal compressive, ductile, and flexural strengths according to the analysis of the data. The highest compressive strength seen after 28 days is 43.47 MPa. The peak tensile strength is 4.53 MPa and the flexural strength comes out to 8.45 MPa. The presence of recovered demolition waste BD helps one to classify this mix as green. <https://doi.org/10.55248/gengpi.6.0325.1276>
8. Bolledula Bhanu Prakash , Vanam Sameer Kumar (2025) The focus of the project includes both Ground Granulated Blast Furnace Slag (GGBS) and onion peel ashes (OPA) have been investigated as partial substitutes for cement in concrete. The objective is to reduce decrease dependence on Portland cement, and improve the sustainability of concrete. The GGBS & OPA both are replaced in place of cement by maintaining GGBS as constant with 15% and OPA with ascending follows from 0%, 4%, 8%, 12%, 15% & 20% in M30 Solid. Based on results as considered the compressive quality, ductile quality & flexural quality attained maximum strength at

percentage of replacing 12%OPA+15%GGBS. The maximum Compressive strength quality gained for 28 days is 38.53 MPa. The maximum Tensile strength quality gained for 28 days is 3.02 MPa. The maximum Compressive strength quality gained for 28 days is 6.08 MPa. It can be referred as green concrete due to the replacement of agro based waste OPA. <https://www.doi.org/10.58257/IJPREMS39567>

III. METHODOLOGY

The Methodology specifies the materials utilized instead of cement for this study:

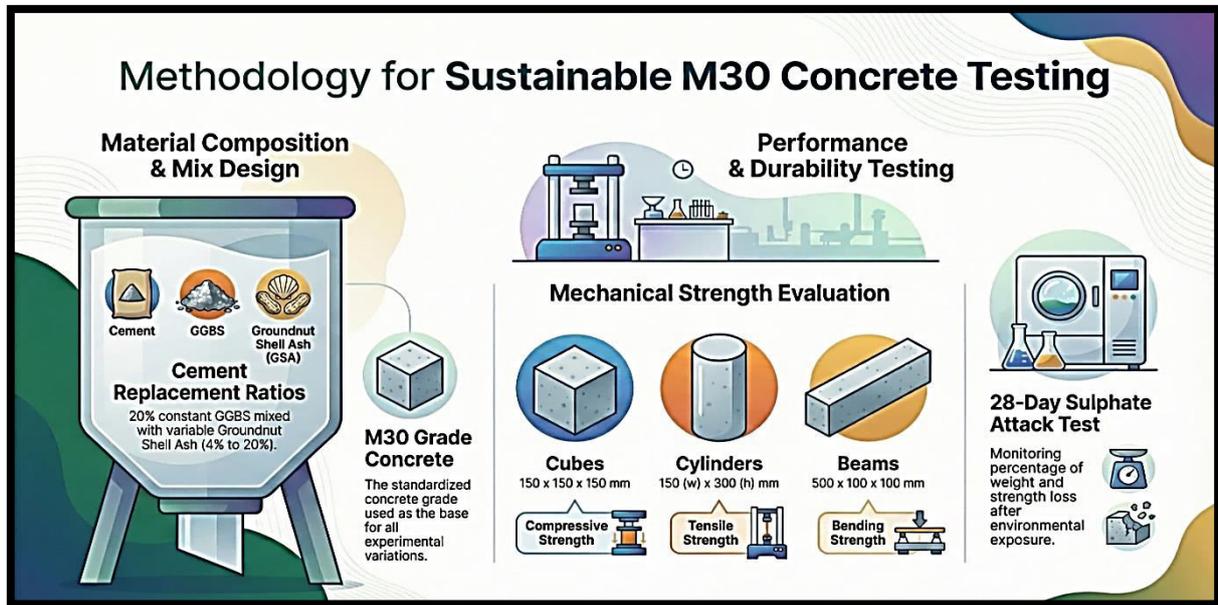


Fig 2: Steps involved in methodology of with respect to proxies

IV. EXPERIMENTAL RESULTS

TABLE NO 1: MIX PROPORTION OF M30

Grade	M30
Proportion	1:1.82:2.51
W/C ratio	0.42
Cement	388.25 kg/m ³
Fine Aggregate	706.7 kg/m ³
Coarse Aggregate	977.47 kg/m ³
Water	195 Liters

TABLE NO 2 TEST RESULTS OF COMPRESSIVE STRENGTH AT 7 DAYS, 14 DAYS & 28 DAYS:

Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0% GSA + 0% GGBS	25.61	30.91	36.36
4% GSA + 20% GGBS	26.32	31.42	37.53
8% GSA + 20% GGBS	26.78	31.73	37.98
12% GSA + 20% GGBS	27.19	32.19	38.84
16% GSA + 20% GGBS	23.25	26.18	32.43
20% GSA + 20% GGBS	21.13	22.78	28.56

TABLE NO 3 TEST RESULTS OF SPLIT TENSILE STRENGTH AT 7 DAYS, 14 DAYS & 28 DAYS:

Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0% GSA + 0% GGBS	1.59	2.08	3.08
4% GSA + 20% GGBS	1.91	2.79	3.78
8% GSA + 20% GGBS	2.45	3.24	4.36
12% GSA + 20% GGBS	3.02	3.89	4.92
16% GSA + 20% GGBS	1.45	1.78	2.85
20% GSA + 20% GGBS	0.87	1.09	1.89

TABLE NO 4 TEST RESULTS OF FLEXURAL STRENGTH AT 7 DAYS, 14 DAYS & 28 DAYS:

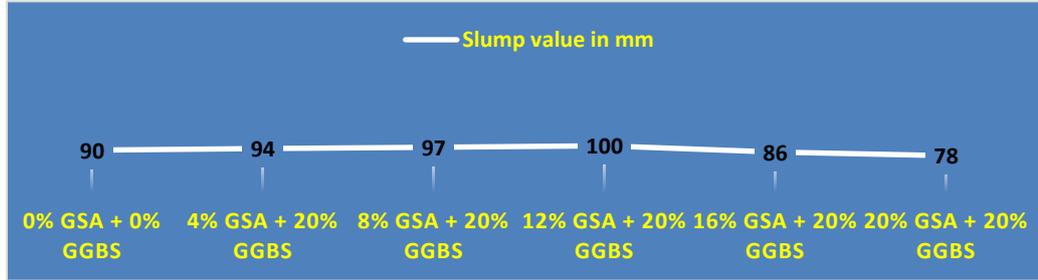
Mix % Replacement	7 days in Mpa	14 days in Mpa	28 days in Mpa
0% GSA + 0% GGBS	3.58	4.86	5.69
4% GSA + 20% GGBS	3.96	5.34	6.18
8% GSA + 20% GGBS	4.39	5.91	6.76
12% GSA + 20% GGBS	4.87	6.48	7.25
16% GSA + 20% GGBS	2.97	3.95	4.88
20% GSA + 20% GGBS	2.38	3.15	4.26

TABLE NO 5 TEST RESULTS OF % WEIGHT LOSS FOR 28 DAYS:

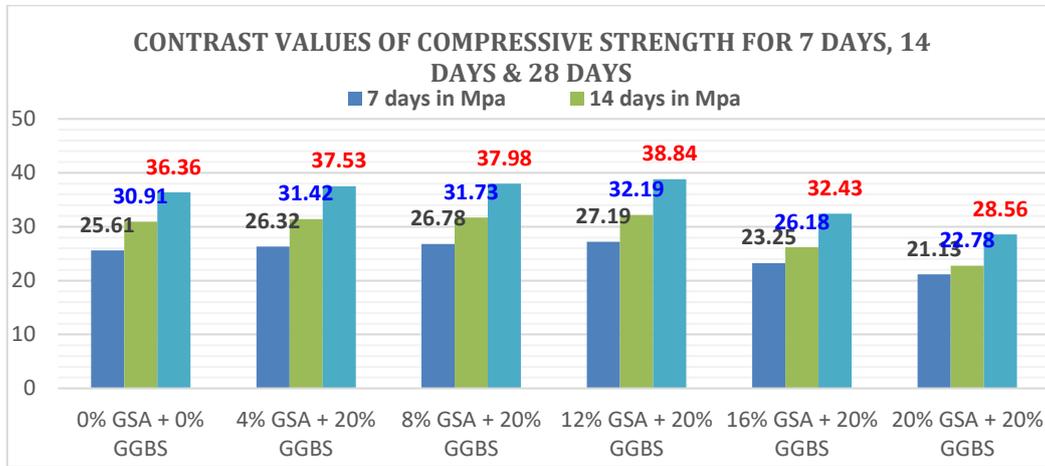
Mix % Replacement	Weight Before (g)	Weight after 28 days in Na ₂ SO ₄ (g)	% Weight Loss
0% GSA + 0% GGBS	8120	8013	1.31
4% GSA + 20% GGBS	8121	8046	0.92
8% GSA + 20% GGBS	8117	8049	0.83
12% GSA + 20% GGBS	8125	8072	0.65
16% GSA + 20% GGBS	8108	7992	1.43
20% GSA + 20% GGBS	8078	7906	2.12

TABLE NO 6 TEST RESULTS OF % STRENGTH LOSS FOR 28 DAYS:

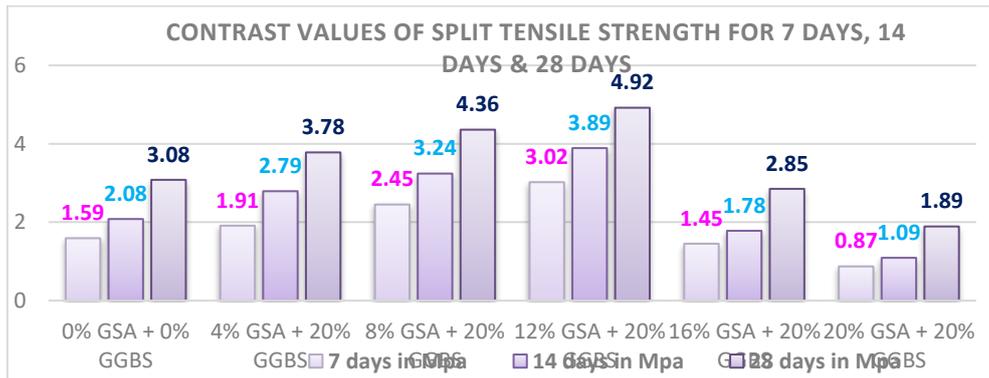
Mix % Replacement	Strength Before (MPa)	Strength after 28 days in Na ₂ SO ₄ (MPa)	% Strength Loss
0% GSA + 0% GGBS	36.36	35.05	3.6
4% GSA + 20% GGBS	37.53	36.43	2.93
8% GSA + 20% GGBS	37.98	36.95	2.71
12% GSA + 20% GGBS	38.84	37.89	2.44
16% GSA + 20% GGBS	32.43	31.05	4.25
20% GSA + 20% GGBS	28.56	26.85	5.98



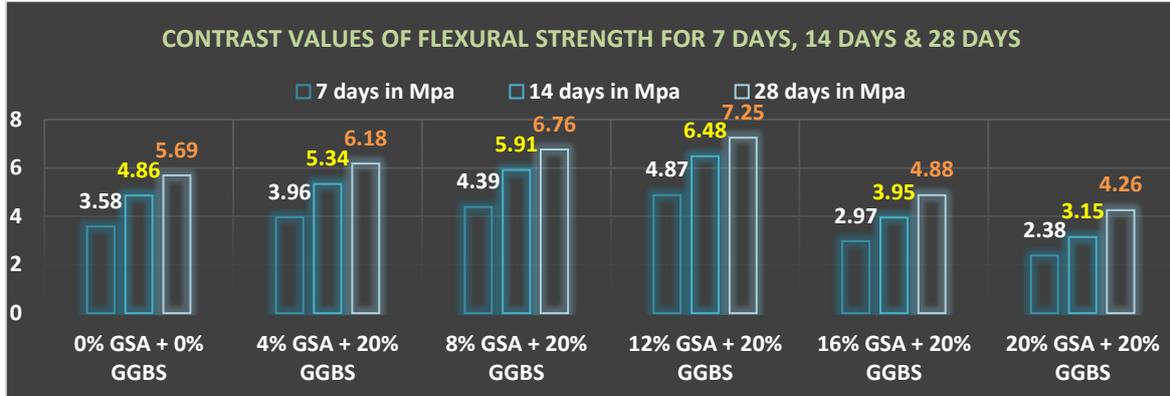
GRAPH NO 1 SLUMP CONE VALUES



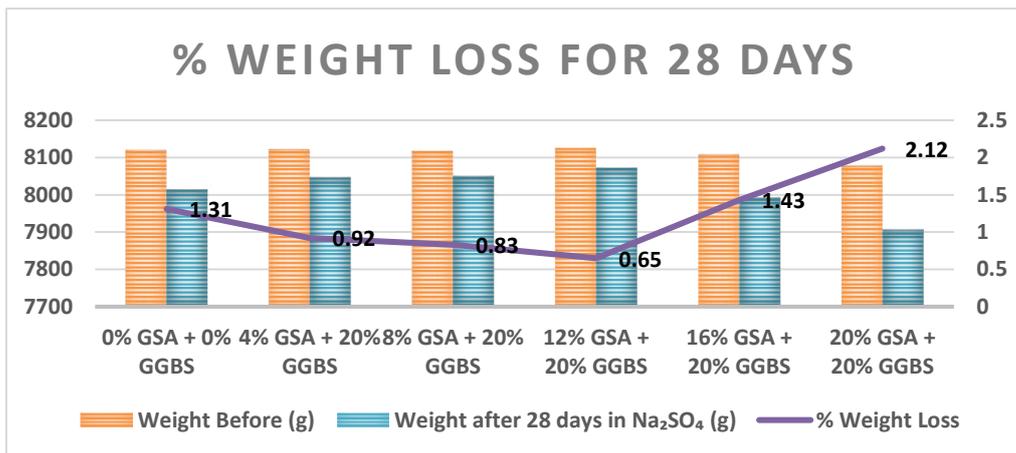
GRAPH NO 2 CONTRAST VALUES OF COMPRESSIVE STRENGTH FOR 7 DAYS, 14 DAYS & 28 DAYS



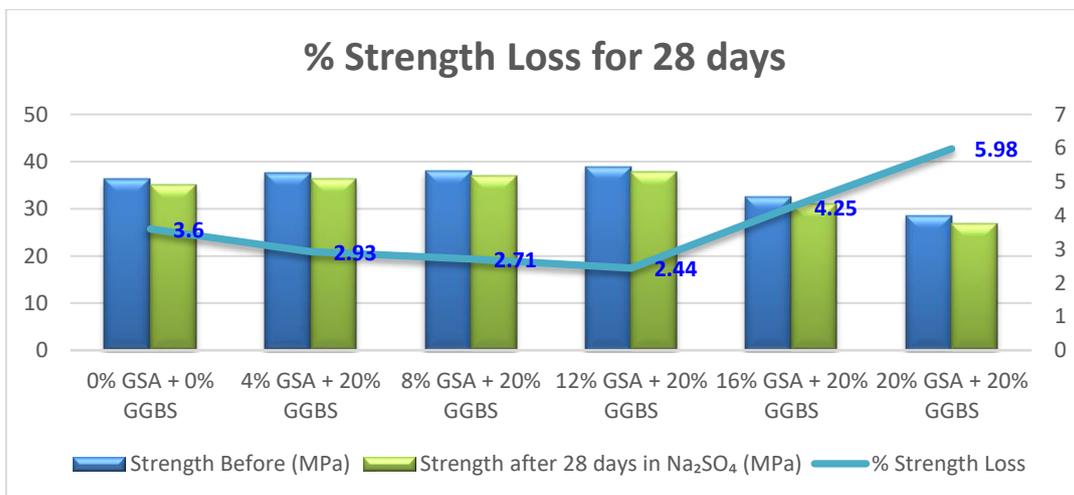
GRAPH NO 3 CONTRAST VALUES OF SPLIT TENSILE STRENGTH FOR 7 DAYS, 14 DAYS & 28 DAYS



GRAPH NO 4 CONTRAST VALUES OF FLEXURAL STRENGTH FOR 7 DAYS, 14 DAYS & 28 DAYS



GRAPH NO 5 DEVELOPMENT OF % WEIGHT LOSS AFTER 28 DAYS



GRAPH NO 6 DEVELOPMENT OF % STRENGTH LOSS AFTER 28 DAYS

V. CONCLUSION

Considering the aforementioned ideas and events, this paper can be finished by stressing on the following points:

- * The result clearly shows how well GGBS and GSA can be used to replace cement in M30 Solid. In this case, 20% GGBS and 0%, 4%, 8%, 12%, 15%, and 20% GSA were kept the same.
- * Given the flexural, ductile, and compressive properties attained, the greatest strength was attained at 12% GSA + 20% GGBS replacement percentage.
- * At 28 days, the maximum compressive strength achieved is 38.53 MPa.
- * The maximum 28-day Tensile strength score obtained is 3.02 MPa.
- * 6.08 MPa is the maximum compressive strength attained in 28 days.
- * The Durability test results of sulphate resistance attack show their % weight loss & % Strength loss as 0.65 & 2.44 for the mix replacement of 12% GSA + 20% GGBS has their best.
- * Replacing agro-based waste GSA qualifies green concrete as its name.

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