International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Investigation of Mechanical Properties of conventional concrete incorporating GGBS and Waste foundry sand

P.Himaja[*1], Dr. B. Jayarami reddy[*2], Mr. D. Mohammed rafi[*3]

[*1] Post Graduate Student, Department Of Civil Engineering, CRIT, Anantapur, A.P, India
[*2] Professor, Department Of Civil Engineering, Yogi Vemana University, Kadapa, A.P, India.
[*2] Assistant Professor, Department Of Civil Engineering, CRIT, Anantapur, A.P, India.

ABSTRACT :

Cement and high-quality aggregates are fundamental materials in construction. However, the rising demand for these materials has significantly increased construction costs, making it difficult for lower and middle-income families to build their homes. Research institutions are actively seeking alternative materials to mitigate construction expenses. This project explores the use of waste materials to address this issue.

In this study, Ground Granulated Blast Furnace Slag (GGBS) and Waste Foundry Sand were utilized as partial replacements for cement and fine aggregates, respectively. Cement, being the most expensive component of concrete, presents an opportunity for cost reduction by substituting it with more sustainable and locally sourced materials like GGBS. This not only aids in waste management but also alleviates the financial burden associated with concrete and housing.

GGBS, derived from industrial processes, has garnered global interest due to its potential for large-scale application in construction. Waste Foundry Sand, a high-quality silica sand produced from ferrous and nonferrous metal industries, is typically used as a moulding material. After multiple uses, this sand can be repurposed as a filling material.

The experimental investigation focused on evaluating the strength properties of concrete with varying proportions of GGBS and Waste Foundry Sand. An M30 mix design was employed, and tests including compression, split tensile strength, flexural strength, and workability were conducted at 28, 56, and 90 days, with river sand replaced at different percentages (0%, 10%, 20%, 30%, 40%, 50%, and 60%) and 20% GGBS incorporated. Additionally, compressive strength tests were performed on cement mortar cubes to determine the optimal GGBS replacement percentage.

Keywords: GGBS, Waste Foundry Sand, Compressive Strength, Split Tensile Strength, Flexural Strength Test

INTRODUCTION :

The term "concrete" originates from the Latin word "concretus," which means compact or condensed. Throughout history, concrete has been widely used in construction. It is a composite material made up of coarse aggregates, such as gravel or crushed stone, fine aggregates like sand, and a binding agent known as hydrated cement.

In the broadest sense, concrete refers to any mass or product created using a cementing medium, typically resulting from the reaction between hydraulic cement and water. For concrete to be deemed effective, it must perform well in both its hardened state and while in its fresh state during transport from the mixer to the formwork. In its fresh state, the mixture must have the right consistency for proper compaction and should be cohesive enough to avoid segregation during transport and placement.

Regarding its hardened state, the primary requirement is sufficient compressive strength. Numerous properties of concrete, such as density, impermeability, durability, abrasion resistance, impact resistance, tensile strength, and sulfate resistance, are linked to this strength.

Waste Foundry Sand (WFS)

Because of the steady rise in waste materials and industrial byproducts, efficient waste management has become a major global environmental concern. The use of scraps and by-products has emerged as an alluring disposal option as landfilling space becomes more scarce and expenses grow. Among these industrial by-products is Waste Foundry Sand (WFS).

Millions of tonnes of byproducts are produced worldwide by the ferrous and "non-fer metal casting industry combined. An estimated 2 million tonnes of sand from waste foundries are produced annually in India alone. With its long history of effective usage as a landfilling material, WFS is predominantly an afterthought of the steel castings industry. However, the escalating costs of disposal are making this practice increasingly problematic.

Metal foundries consume large quantities of sand during the the casting procedure. Generally speaking, foundries repurpose and recycle their sand. Sand that is no longer suitable for reuse is called "Waste Foundry Sand."

The foundry industry generates significant material waste during the casting process. Brass, bronze, copper, aluminium, and steel are examples of non-ferrous metals. Cast steel and iron are examples of ferrous metals. Since moulds predominantly use moulding sand, which is easily bonded to binders and organic components, readily available, affordable, and resistant to thermal damage, over 70% of the overall material is made up of sand. Casting and moulding operations at foundries usually need the use of premium, specially-sized silica sand. This leftover foundry sand has a significant amount of particles and is frequently black in colour.

Induction, electric arc, cupola, and other types of furnaces, as well as finishing techniques like blasting, grinding, and coating, all affect the chemical and physical properties of WFS.

II.MATERIALS AND METHODOLOGY

The materials in this experiment used are Cement, Fine aggregate, Coarse aggregate, Waste foundry sand, GGBS and Super plasticizer.

Cement :

Ultra tech cement, also known as ordinary Portland cement, with a grade of 53 that is confirmative to IS: 12269-1987 was still in use. In accordance with IS 4031 (part II)-1988, its physical attributes were examined.

Fine aggregate:

This investigation's River sand, a fine aggregate, was easily accessible in the region. The sand was free of clayey elements, salt, and biological pollutants. The sand was examined for a number of characteristics in compliance with IS 2386-1963, including bulk density and specific gravity. The fine aggregate met the required standards.

Coarse aggregate:

The coarse aggregate was made of machine-crushed, locally procured, angular granite metal that was nominally 20 mm in size.. It was devoid of contaminants including dust, clay fragments, and other organic materials.IS 2386-1963 was followed in the examination of the physical properties of coarse aggregate.

Waste foundry sand:

A byproduct of a metal casting business, waste sand from finds (WFS) is mostly produced during the moulding process. Because it usually contains silica s clay, and additional ingredients, it can be reused in a variety of ways. The disposal of WFS poses environmental challenges, as large quantities are sent to landfills, contributing to waste management issues. Incorporating WFS into concrete can enhance its properties, improving strength and durability while reducing the demand for natural aggregates. Research indicates that using WFS in concrete mixes can lead to cost savings and lower environmental impact. The use of WFS not only addresses waste disposal concerns but also helps conserve natural resources. Ongoing To fully utilise WFS and create standards for its safe and efficient implementation in civil engineering projects, study is necessary. The sand was examined for a number of characteristics in compliance with IS 2386-1963, including bulk density and specific gravity.

Water:

Water that is readily available locally, acceptable for consumption and free of dangerously high levels of organic compounds, salts, sugars, oils, and alkaline solutions, For mixing and curing, substances that could damage concrete or steel are used.

GGBS:

Slag from ground granular blast furnaces is a byproduct of the iron producing industry. Following the iron ore, melted slag, which is at a temperature of around 15,000 to 16,000 degrees Celsius, floats on top of the molten iron., coal and limestone have been introduced into the furnace.

Super plasticizer:

Polycarboxylate Ether (PCE) tech is the foundation of Sika ViscoCrete, a high-performance superplasticizer. It improves the concrete's flow and workability. while significantly reducing water content, allowing for lower water-cement ratios without compromising strength. Sika ViscoCrete is suitable for a wide range of applications, including high-strength concrete, self-compacting concrete, and precast elements. Its versatility makes it effective in various environmental conditions and for different types of aggregates, including those with supplementary materials like GGBS. Additionally, It enhances concrete's long-term performance and durability, which makes engineers and contractors favour it. Throughout the experimental program, the super plasticiser dosage remained constant at 0.5% of the binder's weight.

III.LITERATURE REVIEW :

This chapter examines the research on the strength properties of concrete made with leftover foundry sand. in place of the fine aggregate and the impact of GGBS on those characteristics.

1. Ghassan Abood Habeeb, Hilmi Bin Mahmud: GGBS (GGBS) made in a Ferro-cement furnace was examined for its qualities. Before performing an XRD study to confirm the existence of amorphous silica particles in the ash, the impact of grinding on the surface area and particle size was investigated.. Without compromising strength, GGBS can effectively replace up to 20% of cement. Concrete from GGBS provided good strength enhancement with a 10% substitute (30.8% increment opposed to the control mix). When GGBS fineness was increased, blended concrete's strength increased relative to larger GGBS and controlled OPC combinations.

2. **Gritsada Sua-iam, Natt Makul:** examined the characteristics of ternary combination of unprocessed GGBS (GGBS), pulverised fuel ash (FA), and Type 1 Portland cement (OPC) in combinations for self-compacting concrete (SCC). The SCC mixes were created with a consistent total powder material content of 550 kg/m3 and a regulated slump flow in the diameter range of 67.5 to 72.5 cm. To replace in powder materials with 20 or 40 weight percent, GGBS and/or FA were utilised. It was determined what the attributes were, both fresh and hardened, in terms of water need, workability, density, development of compressive strength, and ultrasonic pulse velocity. Comparing self-compacting concrete mixtures with simply GGBS or FA to those with ternary blends, the physical qualities of the former showed substantial improvements.

3. Rafat Siddique, Geert de Schutter and Albert Noumowec: gave the findings of an experimental study done to assess the mechanical characteristics of mixes of concrete in which waste foundry sand was used in place of some of the fine aggregate (regular sand). Three weight percentages (10%, 20%, and 30%) of WFS were used in place of fine aggregate. We conducted tests on the characteristics of recently mixed concrete. We measured the material's modulus of elasticity, splitting-tensile strength, flexural durability, and compressive strength at 28, 56, 91, and 365 days. Results from the test showed that using WFS in place of some fine aggregate (sand) increased the strength qualities of plain concrete somewhat. WFS is a useful material for producing high-quality concrete and building supplies.

4.Yogesh Aggarwal, Paratibha Aggarwal, Rafat Siddique, El-Hadj Kadri and Rachid Bennacer: designed concrete mixtures that replace up to 40% utilising discarded foundry sand for the fine aggregates. The evaluation of certain mechanical attributes includes separate compressive and tensile strengths. It is also determined how durable the concrete is in terms of its ability to withstand carbonation and chloride penetration. According to test results, concrete made from industrial byproducts can be strong and long-lasting enough to replace regular concrete. We measured the split-tensile and compressive strengths at 28, 90, and 365 days. There was an observation of the foundry sand mixes' relative strength growth compared to the mixture without foundry sand, or to the control mix.. Thus demonstrating the successful use of sand from the as a substitute material in place of some of the fine particles in concrete.

5. Gurpreet Singh and Rafat Siddique: conducted an experimental study wherein WFS was used in part to replace pure sand in order to assess the concrete mixtures' strength and durability properties. Natural sand was substituted with five weight percentages of WFS: 0%, 5%, 10%, 15%, and 20%. Concrete was subjected to compress and breaking tensile test tests at 7, 28, and 91 hours of age in order to evaluate its strength characteristics. Based on test findings, WFS can be substituted for some fine aggregate in plain concrete. Its strength qualities are somewhat increased.

6. Gurpreet Singh and Rafat Siddique: examined The durability and resilience to abrasion of concrete that contained sand from waste foundries (WFS). In place of sand (fine aggregate), WFS made out of 0%, 5%, 10%, 15%, and 20% by mass. Maintaining a steady water-to-cement ratio and mixture workability of 85 ± 5 mm and 0.40, respectively, was the focus. The properties under investigation included modulus of elasticity, depth of wear measurements for abrasion resistance, compressive strength, and splitting tensile strength. The findings of the tests showed that using WFS instead of sand improved the mechanical properties continuously for a period of 365 days, increasing 3.6–10.4% for the splitting tensile load and 8.3–17% for the 28-day compressive strength, depending on the WFS concentration.

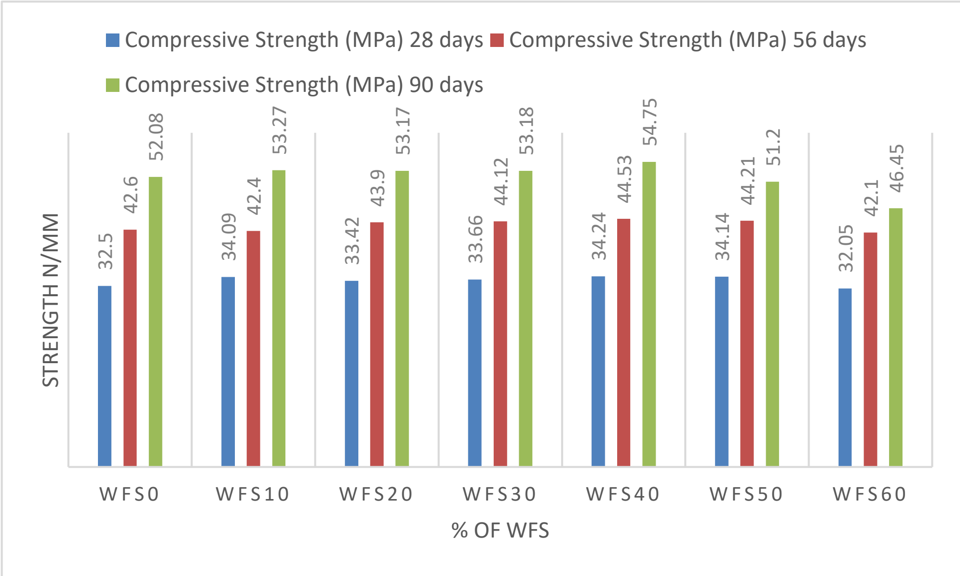
Compressive Strength test

IV.RESULTS AND DISCUSSION :

Cube specimens were tested for compression and ultimate compressive strength was determined from failure load measured using compression testing machine. The average value of compressive strength of 3 specimens for each category at the age of 28 days,56 days ,90 days.

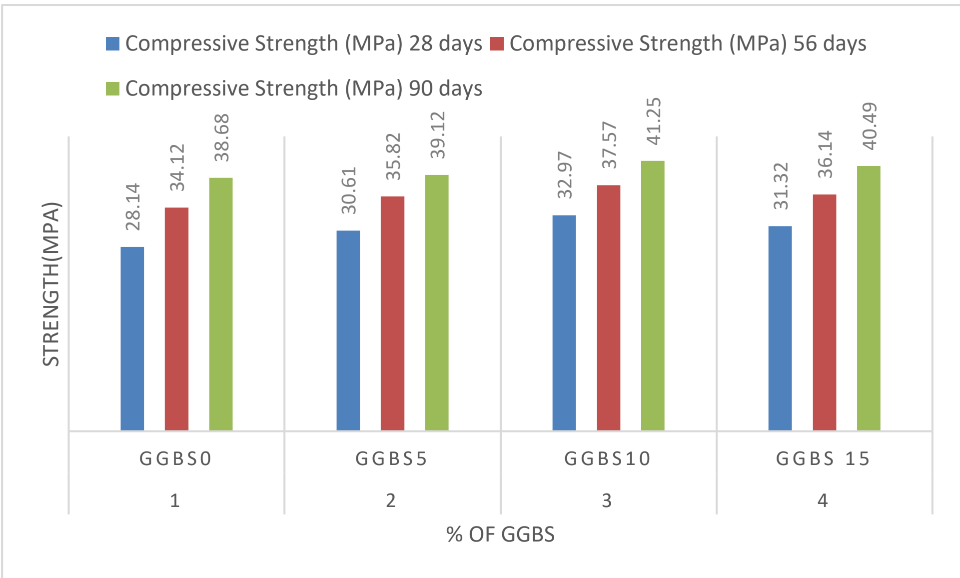
Compressive Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at Different Ages

S.No.	Mix ID	Compressive Strength (MPa)		
		28 days	56 days	90 days
1	WFS0	30.56	34.6	39.08
2	WFS10	31.09	35.4	41.27
3	WFS20	32.42	35.9	42.17
4	WFS30	33.66	36.12	43.18
5	WFS40	34.26	37.53	44.75
6	WFS50	34.14	36.21	41.20
7	WFS60	32.05	32.10	36.45



Compressive Strength of Various Concrete Mixes with Different Percentage of GGBS at Different Ages

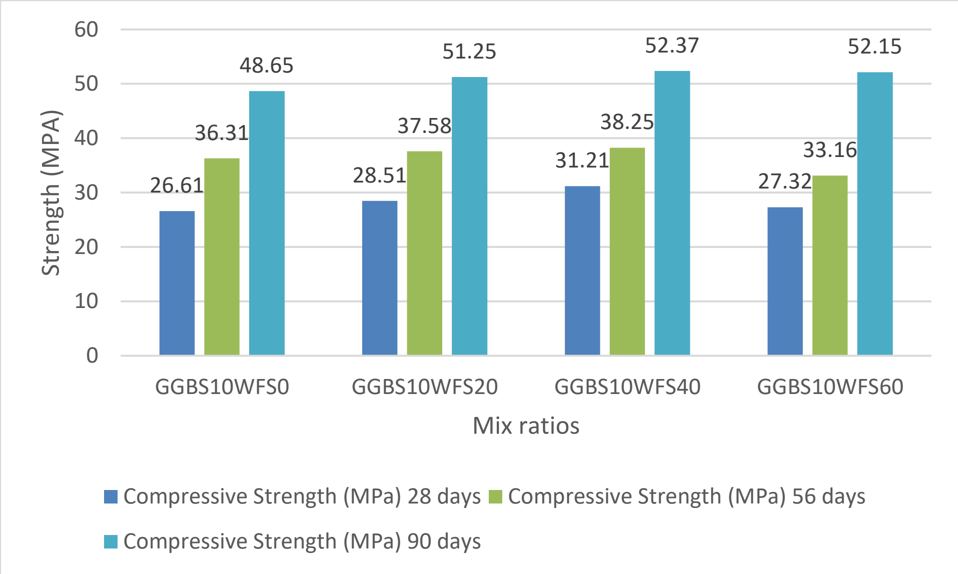
S.No.	Mix ID	Compressive Strength (MPa)		
		28 days	56 days	90 days
1	GGBS0	28.14	34.12	38.68
2	GGBS5	30.61	35.82	39.12
3	GGBS10	32.97	37.57	41.25
4	GGBS 15	31.32	36.14	40.49



Compressive Strength Test of Concrete Mixes with GGBS and Various Percentage of Waste Foundry Sand at Different Ages

S.No.	Mix ID	Compressive Strength (MPa)		
		28 days	56 days	90 days
1	GGBS10WFS0	26.61	36.31	48.65
2	GGBS10WFS20	28.51	37.58	51.25
3	GGBS10WFS40	31.21	38.25	52.37

4	GGBS10WFS60	27.32	33.16	52.15



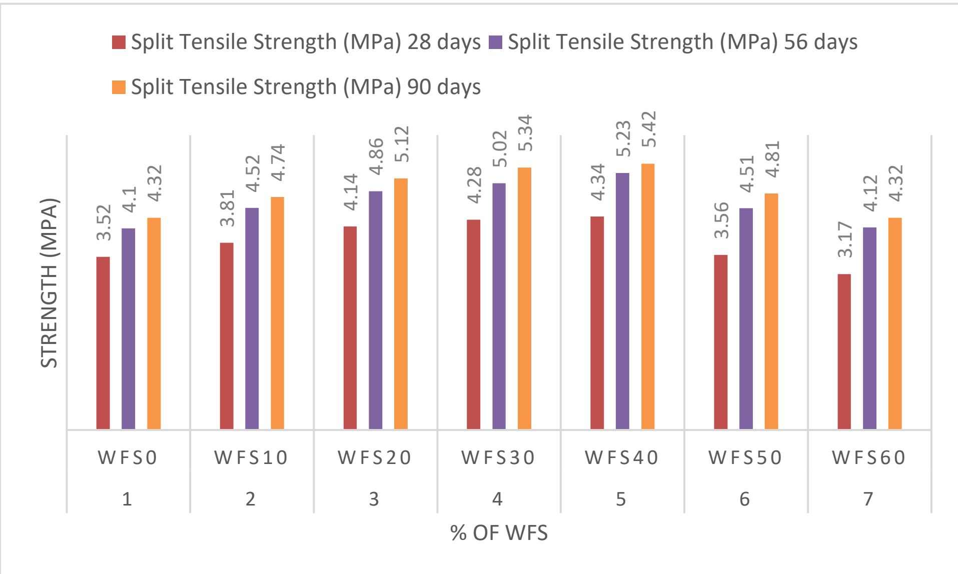
Compressive Strength of Concrete Mixes with GGBS and Various Percentage

Split Tensile Strength Test:

The graphical representation of variation of split tensile strength of plain concrete at 56 and 90 days.

Split Tensile Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at Different Ages:

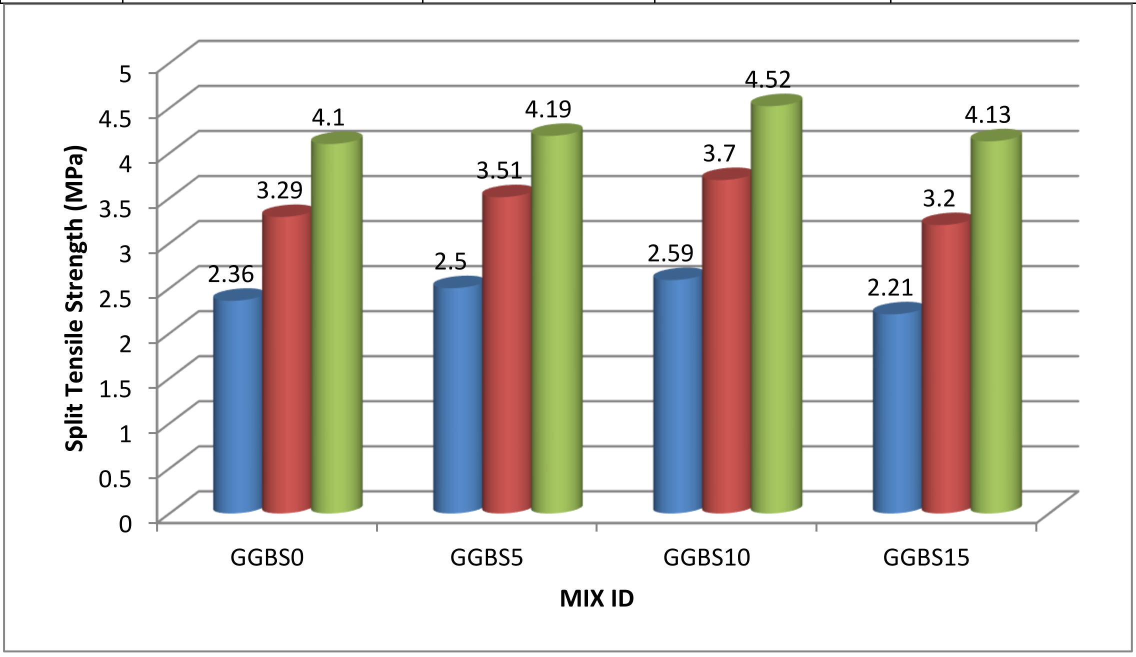
S.No.	Mix ID	Split Tensile Strength (MPa)		
		28 days	56 days	90 days
1	WFS0	3.52	4.1	4.32
2	WFS10	3.81	4.52	4.74
3	WFS20	4.14	4.86	5.12
4	WFS30	4.28	5.02	5.34
5	WFS40	4.34	5.23	5.42
6	WFS50	3.56	4.51	4.81
7	WFS60	3.17	4.12	4.32



Split Tensile Strength of Various Concrete Mixes with Replacement of Fine

Split Tensile Strength of Various Concrete Mixes with GGBS and Different Percentages of Waste Foundry Sand:

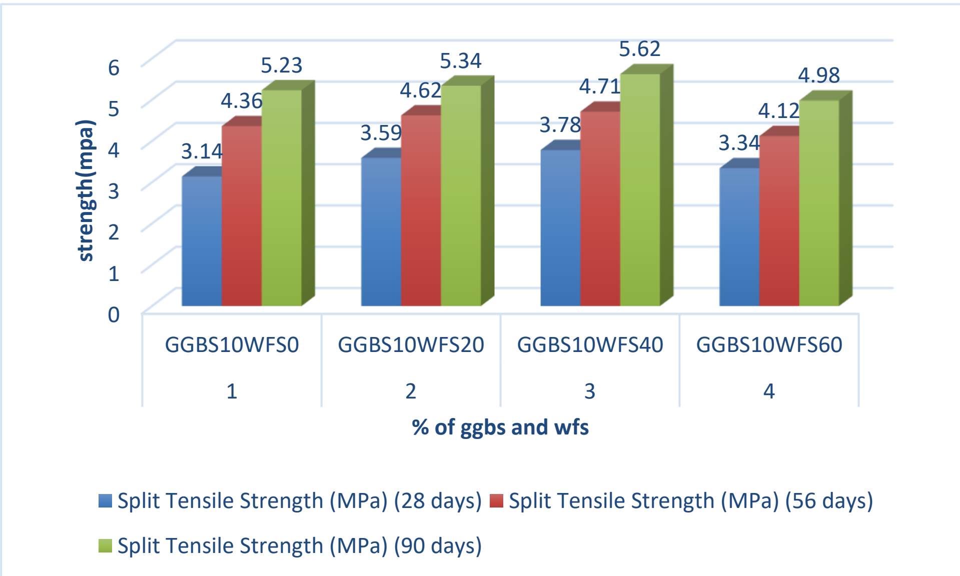
S.No.	Mix ID	Split Tensile Strength (MPa)		
		(28 days)	(56 days)	(90 days)
1	GGBS0	2.36	3.29	4.10
2	GGBS5	2.50	3.51	4.19
3	GGBS10	2.59	3.70	4.52
4	GGBS15	2.21	3.20	4.13



Split Tensile Strength of Various Concrete Mixes with GGBS

Split Tensile Strength Test of Various Concrete Mixes with GGBS and Different Percentages of Waste Foundry Sand:

S.No.	Mix ID	Split Tensile Strength (MPa)		
		(28 days)	(56 days)	(90 days)
1	GGBS10WFS0	3.14	4.36	5.23
2	GGBS10WFS20	3.59	4.62	5.34
3	GGBS10WFS40	3.78	4.71	5.62
4	GGBS10WFS60	3.34	4.12	4.98

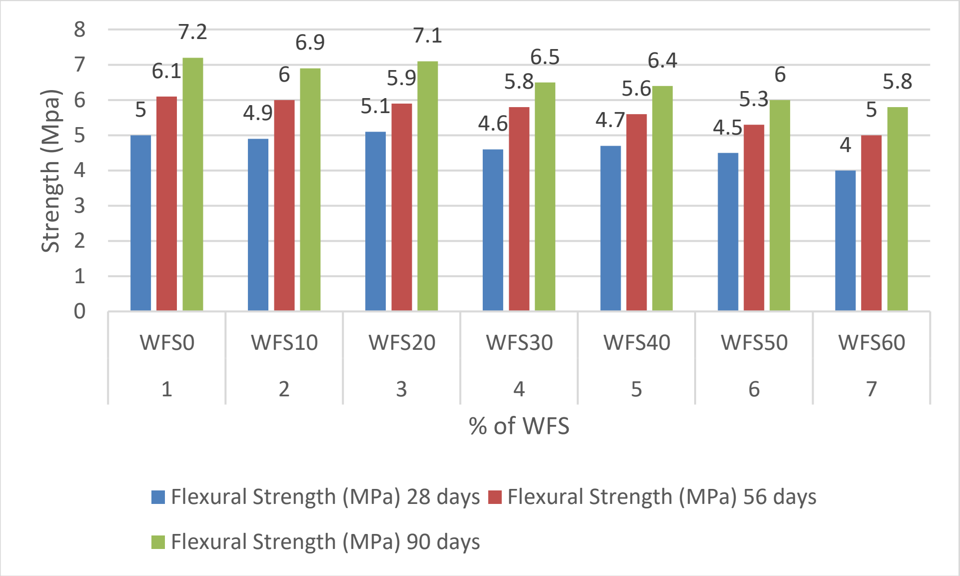


Split Tensile Strength of Various Concrete Mixes with GGBS and Different Percentages of Waste Foundry Sand at 90 days of curing

Flexural Strength Test:

Flexural Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand

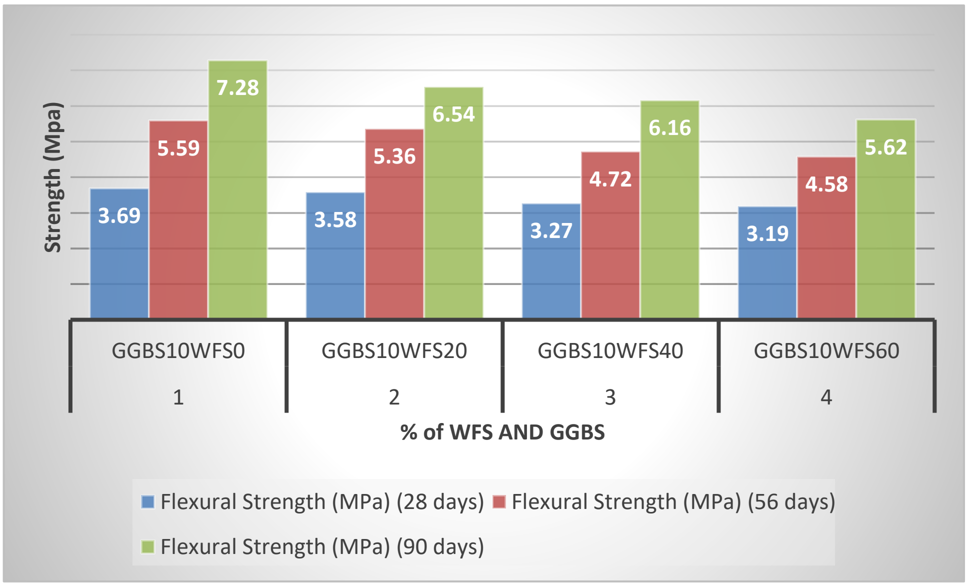
S.No.	Mix ID	Flexural Strength (MPa)		
		28 days	56 days	90 days
1	WFS0	5	6.1	7.2
2	WFS10	4.9	6	6.9
3	WFS20	5.1	5.9	7.1
4	WFS30	4.6	5.8	6.5
5	WFS40	4.7	5.6	6.4
6	WFS50	4.5	5.3	6
7	WFS60	4	5	5.8



Flexural Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand

Flexural Strength of Various Concrete Mixes with GGBS and Different Percentage of Waste Foundry Sand:

S.No.	Mix ID	Flexural Strength (MPa)		
		(28 days)	(56 days)	(90 days)
1	GGBS10WFS0	3.69	5.59	7.28
2	GGBS10WFS20	3.58	5.36	6.54
3	GGBS10WFS40	3.27	4.72	6.16
4	GGBS10WFS60	3.19	4.58	5.62



Flexural Strength of Various Concrete Mixes with GGBS and Different Percentage of Waste Foundry Sand at days of curing

V. CONCLUSION :

- A higher percentage of discarded foundry sand than 40% caused the mixture to become less workable.
- After using GGBS in place of cement in mortar cubes, the strength increased to a maximum of 10% replacement before declining. Thus, 10% replacement is ideal in this case.
- The strength at compression of regular concrete of grade M30 increased up to 40% when waste foundry sand was substituted for fine aggregate, after which there was a noticeable decline in strength. At 40%, maximum strength was attained.
- It took 90 days to achieve an equilibrium strength of 39.08 MPa for the Normal Concrete mix at 60% substitution of fine aggregate, which is less that the goal strength.
- The addition of more waste foundry sand to plain concrete resulted in a decrease in the material's flexural strength.
- It was determined that the best replacement percentage for M30 grade concrete was 10% rice husk ash in place of cement.
- Cement can be substituted by ground granules blast furnace clay (GGBS), which is extracted from the brick-making kiln, but only up to 10% of the time.

VI.REFERENCES :

1. Bhanja, S., & Singh, P. (2009). "Effect of GGBS on the potency and lifespan of concrete." Civil Engineering Materials Journal, 21(3), 223-227.
2. Khatri, S., & Soni, P. (2015). "Utilisation of waste mine sand in concrete." Engineering Studies & Technology International Journal, 4(9), 113–117.
3. Rafat Siddique, Geert de Schutter and Albert Noumowe, (2008), Building & Construction Supplies, vol. 23, pp. 976–980, "Impact of usedfoundry sands on concrete's mechanical properties."
4. Yogesh Agarwal, Paratibha Agarwal, Rafat Siddique, El-Hadj Kadri and Rachid Bennacer, (2010), Construction & Building Materials, vol. 25, pp. 1916–1925, "Durability, strength, and microstructural characteristics of concrete made with usedfoundry sand (UFS)".
5. Gurpreet Singh and Rafat Siddique, (2011), "Effects of substituting sand from waste foundries (WFS) for some sand on concrete's permeability, strength, & ultrasonic pulse velocity," Construction research Building Material, vol. 26, pp. 416–422.
6. Gurpreet Singh and Rafat Siddique, 2011; "Features of concrete that include abrasion resistance and hardness, incorporating waste foundry sand (WFS)"; Materials for Engineering and Construction, vol. 28, pp. 421–426.
7. Rafat Siddique and El-Hadj Kadri, (2011), "Effects of foundry sand and metakaolin on the near-surface characteristics of concrete," study of building materials for construction, vol. 25, pp. 3257–3266.
8. Neelam Pathak and Rafat Siddique, (2012), "Temperature variations and their effects on the properties of self-compacting concrete made with fly ash and wasted foundry sand, Construction & Architectural Materials, vol. 34, pp. 521–521.
9. Satish D. Kenel "Using fly ashes and rice husk to test the force of concrete ash, Vol. 1, Issue 3, pp. 524-534
10. IS 2386-1963 "Concrete Aggregate Test Procedure", Bureau of Indian Rules and Regulations, New Delhi.
11. IS 516-1959 "Test Procedure for Concrete Strength," Bureau of Indian Rules and Regulations, New Delhi.