COMPARATIVE STUDY ON GGBS BASED CONCRETE BY REPLACING FINE AGGREGATE WITH RIVER SAND AND M-SAND

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Abstract

Cement, aggregates, and water are the three main components of concrete, the strongest construction material. The growth of infrastructure in the building industry has led to a greater use of natural river sand on a worldwide scale. Government restrictions on river sand extraction had resulted in unlawful mining and raised the cost of sand. The use of M-sand as a fine aggregate has expanded as a result of the shortage of river sand. Utilising M-sand is made possible by its accessibility, affordable transportation, and controllable size as needed for grading. Only a variety of cutting-edge tactics, including smart material selection, contemporary techniques for eco-efficient operations, and trash recycling, can lead to the building industry's sustainable development. This research compares the use of GGBS as a partial substitute for cement in Natural River Sand and M-Sand when added in various amounts (0%, 5%, 10%, 15%, 20%, 25%). To ascertain the ideal proportion of GGBS replacement in cement using both River sand and M-Sand as fine aggregate in concrete, an experimental investigation was carried out. Concrete's compressive strength, splitting tensile strength, flexural strength, and elastic modulus were all tested, and the results for all different mix types were compared. According to the findings, 20% of GGBS replaced in M-Sand concrete exhibits more strength than 20% of GGBS replaced in concrete made with natural river sand.

Keywords: Manufacture sand, river sand, Concrete’s compressive strength, splitting tensile strength, elastic modulus.

1.INTRODUCTION

Materials play a keyrole in the construction sector, which accounts for only 75% of operating costs, so a greater focus on waste based sustainability is recommended. This can improve the overall sustainable development of relevant sectors. The sand from stream due to characteristic handle of steady loss tends to have smoother surface and way better shape. It too carries dampness that’s caught in between the particles. These characters make concrete workability superior. Be that as it may, sediment and clay carried by stream sand can be hurtful to the concrete. Another issue related with waterway sand is that of getting required reviewing with a fineness modulus of 2.4 to 3.1. It has been confirmed and found, at different areas over south India, that it has become increasingly troublesome to urge stream sand of reliable quality in terms of evaluating prerequisites and restricted silt / clay substance. It is since we don't have any control over the common areas.

[1] examine the strength properties of concrete the made with fly ash (FS) in the substitute of cement and copper slag (CS). The two industrial byproducts are CS and FS. [2] examines the impact of replacing fine aggregate and cement in part with industrial wastes such copper slag, steel slag, and GGBS. Initially, copper slag and steel slag were substituted for fine aggregate in varied ratios (0%, 10%, 20%, 30%, 40%, 50%). [3] offers an artificial neural network (ANN) based model. In all, 71 examples were produced using twelve different proportions for the concrete mix.

[4] examination was done on the binding behaviours between the corroded steel bar and copper slag concrete after being exposed to high temperatures. [5] aims to create environmentally friendly building aggregates by using industrial solid waste products like copper slag, which is created during the copper's smelting and refining processes. Due to the presence of Fe_2O_3 (35–60%) and SiO_2 (25–40%) in copper slag, together with trace levels of CaO, Al_2O_3, and CuO, it has the potential to substitute fine aggregates in construction projects.

[6] In order to increase sustainability, this study substituted two major slag-based wastes from industry, namely Ground Granulated Blast Furnace Slag (GGBS) and Copper Slag, for the commonly utilised fly ash and silica sand. [7] examined a total of 7 mix-designs comprising 0–60% fine copper slag aggregates. According to the experimental findings in [8], employing copper slag in lieu of natural sand significantly enhances both abrasion and slake resistance in cured concrete.

[9] Waste copper slag is a typical hazardous solid waste that has several priceless components but hadn't been disposed of appropriately up to this time. In this study, a stepwise extraction method was proposed to recover essential elements from waste copper slag.[10] illustrates that the microstructure of the fibre concrete is densified when copper slag is used in lieu of sand. [1created concretes by using copper slag with ordinary cement [11].

In order to identify the maximum percentage of waste foundry sand (WFS) for partial replacement of fine aggregate in concrete at different ratios [12]. [13] seeks to perform strength and durability studies on slag cement concrete using copper slag (CS) as a partial or total substitute for natural fine aggregates (FNA). [14] In this study, steel slag was substituted for fine aggregate at varied ratios and walnut shell for coarse material at a fixed ratio of 20%. M30 grade concrete is used with a water cement ratio of 0.45.

2. MATERIALS

2.1 Cement

In this research work, Chidambaram-sourced Dalmia 53 grade ordinary Portland cement (OPC), which complies with IS 8112:1989, was employed. Cement's specific gravity was calculated in accordance with IS 4031 part 11. Table 1 listed the chemical and Material characteristics of cement.

Table 1. Material characteristics of cement

Property	Value
Specific gravity	3.06
Time of initial setup	55min

Final time for setting	240min
Logical consistency	32%
Fineness	2%

2.2 Fine Aggregate

The kollidam river near Chidambaram provided the river sand utilised as a fine aggregate, and its physical characteristics, such as specific gravity and fineness modulus, were found to be 2.52 and 2.23, respectively. According to IS 383- 1970, the sand was properly graded and corresponds to zone III. The study of the particle size is depicted in fig. 3.

2.3 M-Sand

M-Sand was collected from local resources in Chidambaram and its physical properties specific gravity and fineness modulus was found to be 2.57 and 3.0. This M-sand as double washed and graded under zone II shown in fig.2

2.4 Coarse Aggregate

Crushed angular aggregate with maximum grain size of 20mm size has been used for this study and its specific gravity determination and sieve analysis for coarse aggregate was performed. As per code IS 383-1970 the aggregate as confirmed as single sized aggregate of nominal size.

2.5 GGBS

Ground granulated blast slag (GGBS), a by-product of producing iron and steel, is created by evaporating molten iron slag from furnaces in water or steam, resulting in a glassy, granular substance that is then dried and crushed into a fine powder. Calcium salt hydrates (CSH), which are more frequently found in building materials like ground granulated blast slag, are responsible for the strength, stiffness, and appearance of concrete. In GGBS, CaO (28-52%), SiO2 (30-40%), Al2O3 (10-22%), and MgO (1-16%) are the most common materials.Crushed granulated blast furnace slag was utilised as a cementious component in concrete because it has a particle size that is significantly smaller than cement. It was purchased from Astraa Chemicals in Chennai and fulfilled the required specifications.

2.6 Super Plasticizer

Super plasticizers are high range water reducers that are used to make concrete easier to work with and more compact. This study's admixture was Conplast - SP 430.

2.7 Water

The water has to be free of hazardous organic contaminants. According to IS: 456-2000 clause 5.4, potable water is taken into consideration for research projects. In the structural laboratory at Annamalai University, tap water is available and has been used for the creation of concrete and the curing of concrete specimens.

Fig.1 GGBS

Fig. 2 M-Sand

Table 2. Material properties of River sand and M-Sand

Sl. No	Material properties	Bulk density	Specific gravity	Fineness modulus	Type of fine aggregate	Zone	Color	Texture	Size
1	**River sand**	1678 g/m^3	2.52	1.23	Fine	III	Brown	Granular	1.3 - 0.6 mm
2	**M-Sand**	1860 g/m^3	2.57	2	coarser	II	Black	Glassy texture	0.6 – 1.2 mm

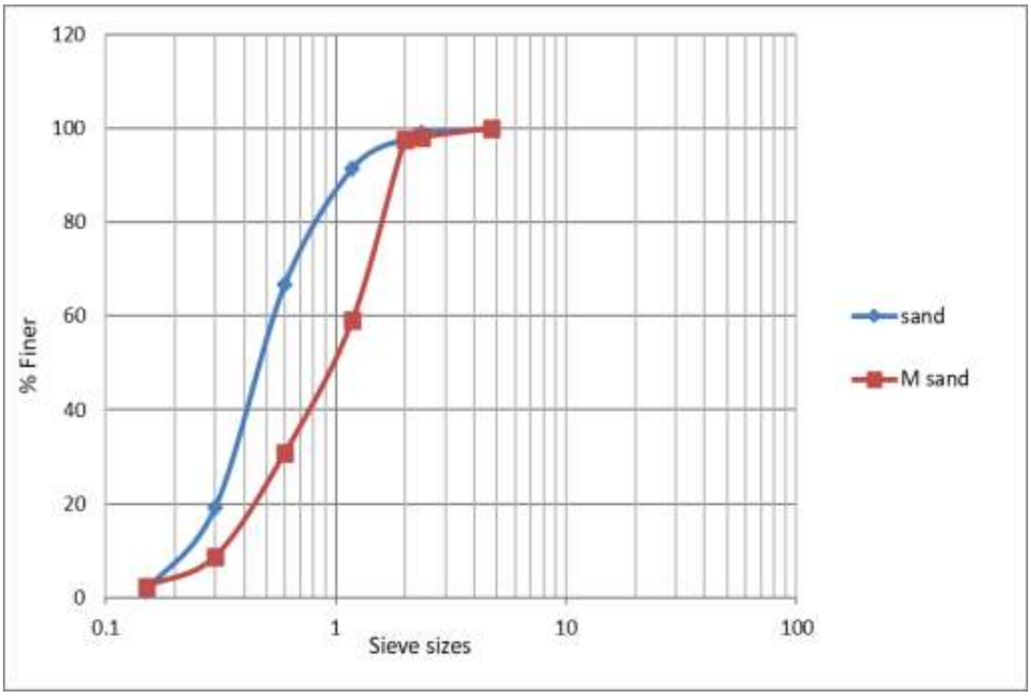

Fig.3 Graph showing the particle sizes of river sand and M-sand

3. EXPERIMENTAL STUDY

3.1 Mix design

In this investigation, M30 concrete mix was regarded as typical concrete. According to IS10262-2009, the concrete mix design for above-grade construction was created. The superplasticizer conplast 430 was used as a water reducer at various concentrations throughout the investigation to maintain the water cement ratio, which was assumed to be 0.4. In table 3, the mix proportion was displayed. In order to find the ideal percentage of GGBS replacement level in natural river sand, the first concrete mix was created using natural river sand as fine aggregate and substituting cement with GGBS with varied percentages (0%, 5%, 10%, 15%, 20%, 25%). The concrete mix was then created using M-sand as the fine aggregate and GGBS in varied percentages (0%, 5%, 10%, 15%, 20%, 25%) in place of cement to find the ideal amount of GGBS replacement in M-sand.

Concrete was cast in 150mm x 150mm x 150mm cubes to test compressive strength, 150mm x 300mm cylinders to test split tensile and modulus of elasticity, and 100mm x 100mm x 500mm prisms to test flexural strength for each mix with various replacement levels. All specimens are tightly compressed in a table vibrator, demoulded after 24 hours, and then cured for 28 days by submersion in water.

Table. 3 mix proportion

Sl. No	Mix	Cement	GGBS	River Sand	M-Sand	Coarse aggregate	Admixture litre	Water litre
1.	M_{CC}	383	-	634	-	1299	3.064	153
2.	RM_1	363.85	19.15	634	-	1299	3.064	153
3.	RM_2	344.7	38.3	634	-	1299	2.681	153
4.	RM_3	325.55	57.45	634	-	1299	2.298	153
5.	RM_4	306.4	76.60	634	-	1299	1.915	153
6.	RM_5	287.25	95.75	634	-	1299	1.532	153
7.	M_{CM}	383	-	-	683.21	1259	3.064	153
8.	MM_1	363.85	19.15	-	683.21	1259	3.064	153
9.	MM_2	344.7	38.3	-	683.21	1259	2.681	153
10.	MM_3	325.55	57.45	-	683.21	1259	2.298	153
11.	MM_4	306.4	76.60	-	683.21	1259	1.915	153
12.	MM_5	287.25	95.75	-	683.21	1259	1.532	153

3.2 Specimen Preparation

The cement and fine aggregate were first mixed together without any lumps and two-third of the required water was first added to the mix and mixed thoroughly then the remaining water was added to get a uniform and homogeneous concrete mix. The chemical admixture, conplast sp 430 was added to the mix as water reducing

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agent. The admixture dosage as gradually increased from 0 to 1% of cement content to obtain the required workability and the slump value is measured.

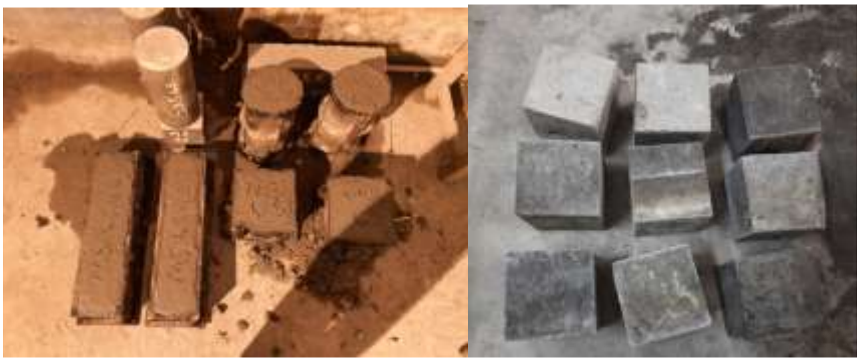

Fig.4 casting of specimens

4. RESULTS AND DISCUSSIONS

The experimental study's test results on the mechanical qualities of hardened concrete, including its compressive strength, split tensile strength, flexural strength, and elastic modulus, are detailed below.

4.1 Results for Compressive Strength

The compressive strength tests were carried out using a compression testing machine in accordance with IS:516-1959. The 150mm-size cubes in figure 5 were studied at 7 and 28 days old. For each concrete combination, three cubes were tested. Table 4 displays the average value for the compressive strength for the three samples.

Table 4. Compressive strength results

MIX ID	FINE AGGREGATE	GGBS	COMPRESSIVE STRENGTH RESULTS(N/mm^2)	
			7DAYS	28 DAYS
M_{CC}	RIVER SAND	0%	31.77	42.53
RM_1		5%	32.80	42.58
RM_2		10%	33.45	42.86
RM_3		15%	33.79	43.73
RM_4		20%	35.58	44.79
RM_5		25%	34.23	43.65
M_{CM}	M-SAND	0%	33.94	45.30
MM_1		5%	34.32	45.76
MM_2		10%	35.74	46.32

MM_3		15%	36.46	46.83
MM_4		20%	38.03	47.95
MM_5		25%	37.56	46.64

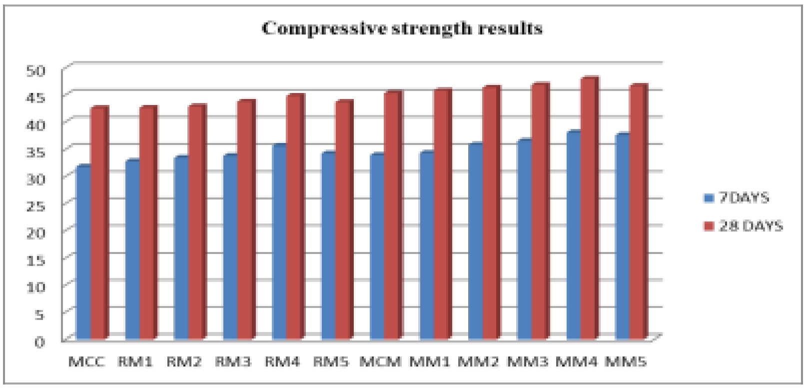

Fig 5. Compressive strength results on 7 and 28 days

Fig.6 Testing and Failure modes of specimens

4.2 Split Tensile Strength

The test was performed in accordance with IS 5816-1999, which is described in procedure 7, to assess the tensile strength of the concrete at 28 days on a 150 mm diameter and 300 mm height cylinder. For each of the concrete combinations, three cylinders were tested. Table 5 displays the average value for the three samples as the split tensile strength.

Table 5. Split tensile strength results

MIX ID	**FINE AGGREGATE**	**GGBS**	**SPLIT TENSILE STRENGTH RESULTS(N/mm^2)**	
			7DAYS	**28 DAYS**
M_{CC}	RIVER SAND	0%	3.56	4.80
RM_1		5%	3.66	4.89
RM_2		10%	3.73	4.98

RM_3		15%	3.91	5.04
RM_4		20%	4.09	5.12
RM_5		25%	3.82	5.02
M_{CM}	M-SAND	0%	3.78	5.08
MM_1		5%	3.86	5.15
MM_2		10%	3.91	5.24
MM_3		15%	4.04	5.37
MM_4		20%	4.15	5.51
MM_5		25%	4.02	5.43

Fig 7. Tensile strength resluts on 7 and 28 days

4.3 Flexural Strength

Concrete samples measuring 100mm x 100mm x 500mm were examined in a flexural testing equipment while being bent in four directions. When river sand and M-sand were combined with GGBS in cement, the flexural strength (Modulus of rupture) was somewhat enhanced. Figure 8 demonstrates the failure specimens of flexural strength testing.

Fig.8 flexural strength testing and failure specimens

Table 6. Flexural strength results

MIX ID	FLEXURAL STRENGTH RESULTS(N/mm^2) 28 DAYS
M_{CC}	5.68
RM_1	5.72
RM_2	5.77
RM_3	5.84
RM_4	5.92
RM_5	5.81
M_{CM}	6.33
MM_1	6.36
MM_2	6.42
MM_3	6.50
MM_4	6.65
MM_5	6.48

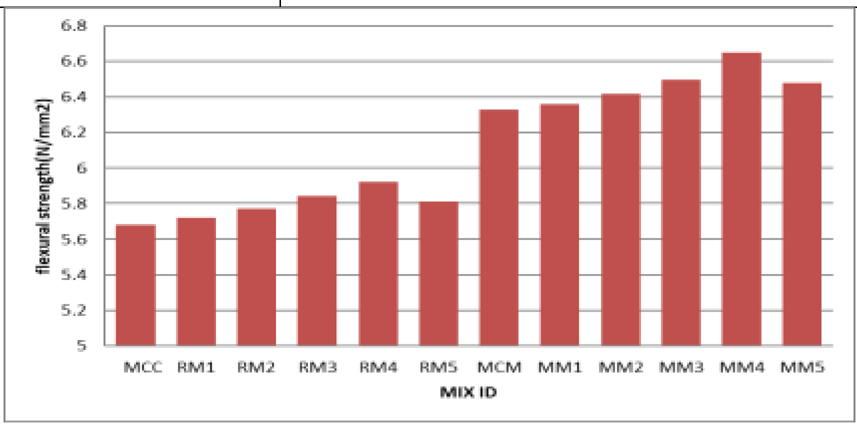

Fig 9. Graph showing the flexural strength results

4.4 Modulus of Elasticity

For the purpose of figuring out the ideal replacement levels of GGBS in river sand and m-sand, cylindrical specimens with dimensions of 150 mm in diameter and 300 mm in height were employed. The stress-strain curve may be used to determine the tested specimens' elastic modulus. As demonstrated in figure 10, the inclusion of GGBS improved the elastic modulus significantly and increased it by 21.92% and 19.28% over standard concrete.

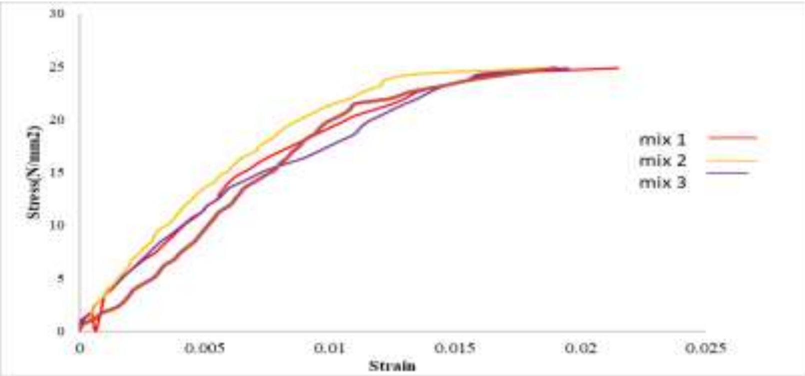

Fig.10 stress strain behavior of modulus of elasticity of concrete.

Fig.11 Modulus of elasticitytesting and failure specimens

Table 7. Modulus of elasticity results

S.NO	MIX	MODULUS OF ELASTICITY E_C X 10^3 N/mm^2
1	Mix cc	29.3

2	Mix ccm	31.24
3	OMR1	33.95
4	OMM2	35.02

5. CONCLUSION

This study evaluates the use of GGBS as a partial substitute for cement in Natural River Sand and M-Sand when applied in various amounts (0%, 5%, 10%, 15%, 20%, and 25%). Both river sand and M-sand were used as the fine aggregate in concrete in an experimental inquiry to identify the proper ratio of GGBS replacement in cement. Following results have been obtained from the GGBS mixes experimental work:

1. Based on the preliminary compressive strength measurements, 20% was determined to be the ideal percentage replacement level of GGBS in both river sand and m-sand.
2. For all mechanical qualities of concrete, M-Sand concrete that contains 20% GGBS in the cement is stronger than ordinary concrete.
3. Because GGBS has a larger surface area than OPC, the crevices between the particles are filled, increasing the strength.
4. The strength decreased because there was less GGBS above the optimal replacement level.
5. The strength decreased above the GGBS optimal replacement level due to increased bleeding and decreased particle water absorption.
6. GGBS provides higher strength and a dense particle packing structure when used in place of cement.
7. Compared to standard concrete, the flexural strength improves by 2% and 3%, respectively.

Nomenclature

M sand - Manufacture Sand

GGBS - Ground Granulated Blast Salg

CSH - Calcium Salt Hydrates

Fs - Fly ash

CS - Copper Slag

ANN - Artificial Neural Network

WFS - Waste Foundry Sand

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