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Effects on Properties of Concrete of Partial Replacement of Cement and Coarse Aggregate by GGBS and Demolished Building Waste

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Abstract – The advancement of concrete technology can reduce the consumption of natural resources and lessen the burden of pollutants on the environment. Nowadays large amounts of Ground Granulated Blast Furnace Slag (GGBS) are generated in thermal industries with an important impact on the environment. In recent years, many researchers have established that the use of supplementary cementitious materials like Ground Granulated Blast furnace slag (GGBS), fly ash (FA), silica fume, rice husk ash (RHA), etc, can not only improve the various properties of concrete but also can contribute to the economy in construction costs. This research work describes the feasibility of using the thermal industry waste GGBS and demolished building waste as a partial replacement for cement and coarse aggregate as in concrete production.

By using these waste materials in concrete for new projects we can also reduce the emission of CO_2 which is generated while production of Cement in the cement factory which is very dangerous for the environment.

The cement has been replaced by GGBS accordingly in the range of 0% (without GGBS), 20%, 30% & 40%, and replacing coarse aggregate by RCA in range of 15%, 30% & 45% weight of cement and aggregate for M40. Concrete mixtures were produced, tested, and compared in terms of compressive strength with conventional concrete. This test was carried out to evaluate the mechanical properties of the test results for compressive strength for up to 28 days.

Keywords: Cement, Concrete, Environment, Ground Granulated Blast Furnace Slag (GGBS), Recycled Coarse Aggregate.

1. INTRODUCTION

There is a large amount of demolished building waste is generated every year in the world but a very small amount of waste is recycled and reused. Some amount of this waste can be reused in the concrete as Recycled Coarse Aggregate (RCA), this can reduce the demand for Natural Coarse Aggregates in industries and save the environment as well as money.

This research work describes the suitability of using the steel thermal industry waste GGBS and demolished building waste as a partial replacement for cement and coarse aggregates in concrete.

By using these waste materials in concrete for new projects we can also reduce the emission of CO_2 which is generated while production of Cement in the cement factory which is very dangerous for the environment.

2. LITRATURE REVEIV

2.1 A STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH GGBS IN CONCRETE by Mr. Poovarasan

In this study, different percentages of GGBS were used in place of cement to compare the qualities of concrete. The purpose of the current investigation was to determine the compressive strength of concrete of the M20 grade using cubes. Use GGBS as partial replacement of cement by 30%, 40%, and 50%. In this report the highest strength of concrete found at 40% replacement of cement by GGBS.

2.2 An Experimental Study on Partial Replacement of Cement by GGBS and Natural Sand by Quarry Sand in Concrete by Mr. Chaithra H L

In order to make concrete, waste material can be used in place of cement and sand to some extent. GGBS was utilised in the proportions of 30%, 40%, and 50% by weight of cement for the M40 grade mix, and quarry sand in the proportions of 40%, 50%, and 60% by weight of cement. In contrast to the compressive strength, split tensile strength, and flexural strength of hardened concrete, the workability of fresh concrete was examined. When compared to conventional mix concrete, it was found that partially substituting GGBS and Quarry sand for sand and cement greatly increased the concrete's strength. Compression strength tests were run at 7, 28, and 56 days, and at 28 days, flexural and split tensile tests were performed.

2.3 Strength Aspects of Concrete by Partially Replacing Cement by GGBS and Coarse Aggregate by Waste Ceramic Tiles by Mr. Swapna V

Cement and coarse aggregate are partially replaced in this thesis report with Ground Granulated Blast Furnace Slag (GGBS) and salvaged ceramic tiles. With a continuous replacement of cement by GGBS of 25% and coarse aggregate by waste ceramic tiles of various percentages of 5% to 30% with a 5% interval, the strength properties of M30 concrete were examined. We looked at compressive strength, split tensile strength, and flexural strength. The outcomes showed that GGBS has equal properties to regular concrete when 25% of the cement is replaced. Waste ceramic tile mixtures offer stronger strength characteristics than conventional concrete when utilised to replace coarse aggregate up to 25% of the time, and a 30% ceramic tile mix has comparable strength to conventional concrete.

2.4 EXPERIMENTAL INVESTIGATION ON CONCRETE WITH REPLACEMENT OF COARSE AGGREGATE BY DEMOLISHED BUILDING WASTE WITH STEEL FIBER (LATHE WASTE) by Mr. S. Sakthivel

This study focuses on repurposing demolished concrete aggregate (DCA) and introducing Steel Fiber from lathe waste to replace coarse aggregate in concrete at varied ratios of 40, 50, and 60 DCA and 1 percent steel fibre (lathe waste) to reduce demolished building waste creation. The use of Demolished Concrete Aggregate (DCA) and Steel Fiber (Lathe Waste) in a specific concrete with a cure time of 7, 14, or 28 days, as well as different concrete tests such as compressive strength, split tensile strength, and flexural strength. These results of the tests are calculated and compared to those of standard concrete.

2.5 Partial Replacement of Course Aggregate with Demolished Waste along with Adding of Admixture

In metropolitan areas, it is common practise to demolish outdated buildings in order to build more modern ones as a result of rapid urbanisation. Only a tiny portion of demolished concrete is recycled or repurposed, nevertheless. Disposing of demolition trash is challenging due to both rigorous environmental regulations and a lack of dumping sites in urban areas, while quarrying raw materials is becoming increasingly challenging. This study presents the results of experimental research on the impact of partial substitution of cement, FA, and CA by different demolition wastes on the strength and workability of concrete. Design mix concrete of grade M25 (Referral concrete) was made for the research using IS 10262-2009.

3. MATERIALS

3.1 CEMENT

Cement is a kind of construction binder that binds various materials together by setting, hardening, and adhering to them. In this investigation, Portland Cement of Grade OPC 53 was used. Lime (calcium oxide, CaO), silica (silicon dioxide, SiO2), and alumina make up the majority of Portland cement's constituents (alumina dioxide and aluminium oxide). While the lime originates from a calcareous (lime-containing) raw material, the other oxides come from an argillaceous (clayey) source. To reach the appropriate composition, smaller quantities of other raw materials, such as silica sand, iron oxide (Fe2O3), and bauxite—which contains hydrated aluminium, Al(OH)3 can be added.

3.2 GGBS

A glassy, granular product is produced by cooling molten iron slag from a blast furnace in water or steam, which is then dried and crushed into a fine powder to generate GGBS. The use of ground-granulated blast furnace slag, which is highly cementitious and rich in calcium silicate hydrates (CHS), a substance that boosts concrete's strength, improves the material's strength, durability, and appearance. The main components of blast furnace slag are CaO (30-50%), SiO2 (28-38%), Al2O3 (8-24%), and MgO. (1-18%). GGBS has a relative density of 2.85 to 2.95, a specific surface area of 400 to 600 m2/kg, and a particle size distribution of 0.1 to 40 microns. By using GGBS Concrete Cement sets more slowly than concrete made with OPC, but it also maintains its strength for a longer period of time during manufacture, depending on the proportion of GGBS in the cementitious material. Using GGBS in concrete results in lower heats of hydration and slower temperature rises.

3.3 Sand

Sand confined to zone 2 of IS: 383-1970 locally available sand.

3.4 Aggregate and Recycled Aggregate

To make concrete or mortar, inert grains of aggregate like sand, gravel, crushed stones, recycled concrete, and so on are combined with additional binding ingredients to form aggregate. In order to save money, aggregate is used as a filler to increase the volume of the building material since it is less expensive than cement, therefore enhancing its strength, durability, and hardness.

By using readily accessible concrete as an aggregate source for new concrete or other uses, concrete recycling is growing in popularity as a way to preserve natural resources and eliminate the need for disposal. Recycling concrete is a simple process. Concrete that already exists is damaged, taken out, and crushed to create a material that has a certain size and quality. So we use some amount of Recycled Coarse Aggregate (RCA) as some replacement of CA.

Table - 1: AIV Test Results

S. No.	AGGREGATE	AIV %
1.	0 % RCA	18.26
2.	15 % RCA	22.34
3.	30 % RCA	27.13
4.	45 % RCA	35.98

Table -2: AGGREGATE CRUSING VALUE RESULT

S. No.	AGGREGATE	CRUSING VALUE %
1.	0 % RCA	18.08
2.	15 % RCA	21.24
3.	30 % RCA	26.47
4.	45 % RCA	34.83

Table - 3: Water Absorption and Specific Gravity

S. No.	AGGREGATE	S.G.	WATER ABSORBTION %
1.	0 % RCA	2.68	0.72
2.	15 % RCA	2.53	0.98
3.	30 % RCA	2.46	1.58
4.	45 % RCA	2.32	2.44

4. MIX Proportioning

Mix Proportioning as per IS 10262:2009 includes following steps:

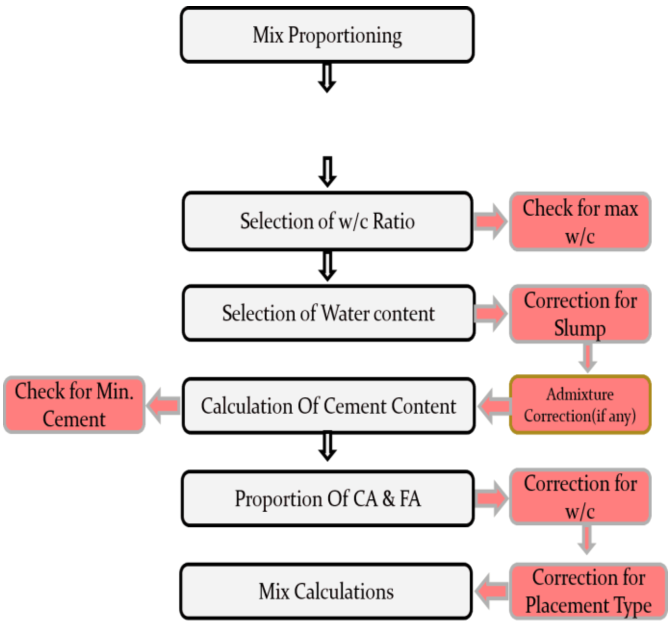


Fig - 1 General steps in Mix Proportioning

5. Experimental Results

C70 stands for 70% Cement, RCA30 stands for 30% Recycled Coarse Aggregate and GGBS30 stands for 30% Ground Granulated Blast Furnace Slag.

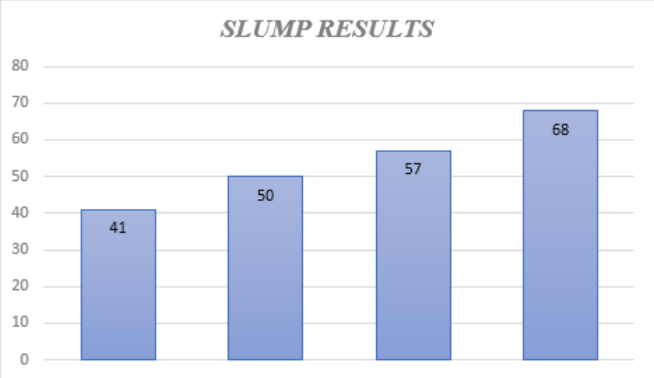
Table - 4:

Trial Mix	Description
M1	C100RCA30GGBS0
M2	C80RCA30GGBS20
M3	C70RCA30GGBS30
M4	C60RCA30GGBS40

5.1 Slump Results:

Table – 5: Slump Result Comparison

SL. NO.	MIX CODE	TRIAL REFERENCE NO.	SLUMP (MM)
1	M1	C100RCA30GGBS0	41
2	M2	C80RCA30GGBS20	50
3	M3	C70RCA30GGBS30	57
4	M4	C60RCA30GGBS40	68



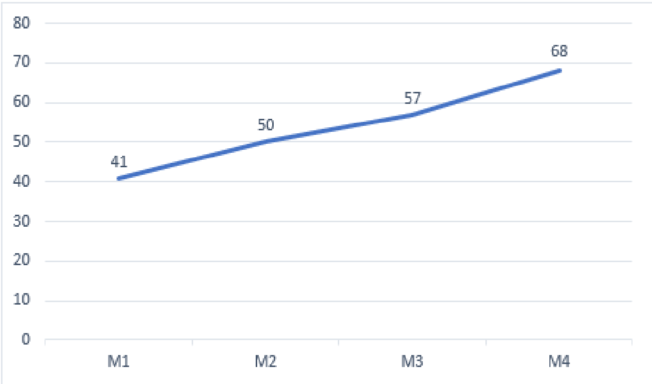


Chart – 1 Slump Results

5.2 Compressive Strength

Table – 6: Compressive Strength Comparison

SL. NO.	MIX CODE	TRIAL REFERENCE NO.	7 Days (MPa)	28 Days (MPa)
1	M1	C100RCA30GGBS0	36.31	51.33
2	M2	C80RCA30GGBS20	35.30	52.15
3	M3	C70RCA30GGBS30	37.82	54.10
4	M4	C60RCA30GGBS40	31.73	48.58

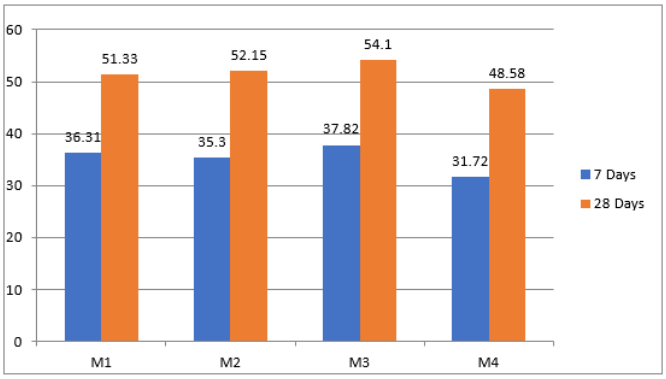


Chart – 2 Compressive Strength Comparison

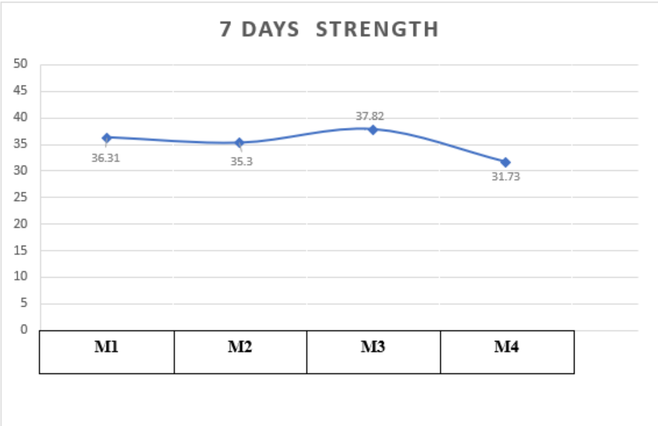


Chart – 3 Compressive Strength at 7 Days

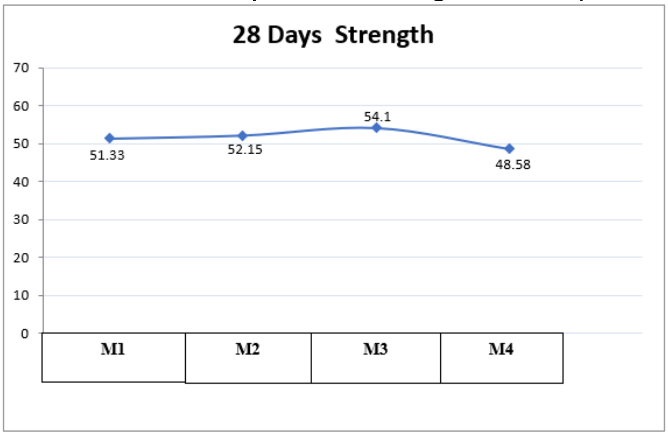
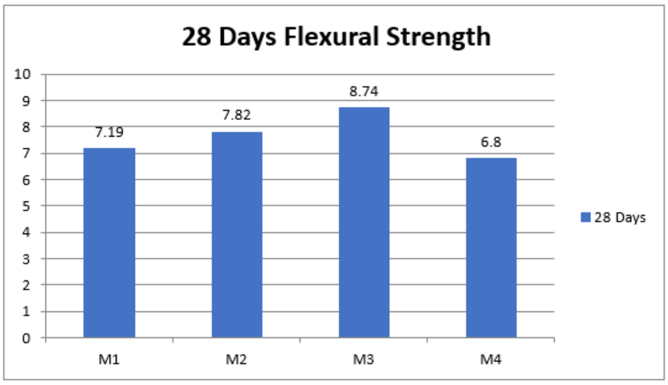


Chart – 4 Compressive Strength at 28 Days

5.3 FLEXURAL STRENGTH

Table – 7: Flexural Strength Comparison

SL. NO.	MIX CODE	TRIAL REFERENCE NO.	28 Days (MPa)
1	M1	C100RCA30GGBS0	7.19
2	M2	C80RCA30GGBS20	7.82
3	M3	C70RCA30GGBS30	8.74
4	M4	C60RCA30GGBS40	6.80



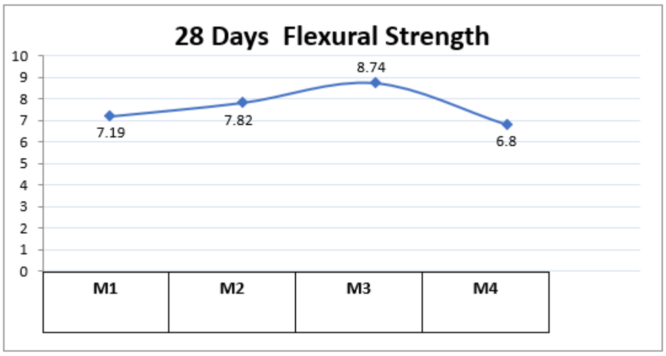


Chart – 5 Flexural Strength at 28 Days

5.4 SPLIT TENSILE STRENGTH

TABLE – 8: Split Tensile Strength Comparison

SL. NO.	MIX CODE	TRIAL REFERENCE NO.	28 Days (MPa)
1	M1	C100RCA30GGBS0	4.35
2	M2	C80RCA30GGBS20	4.66
3	M3	C70RCA30GGBS30	5.21
4	M4	C60RCA30GGBS40	4.27

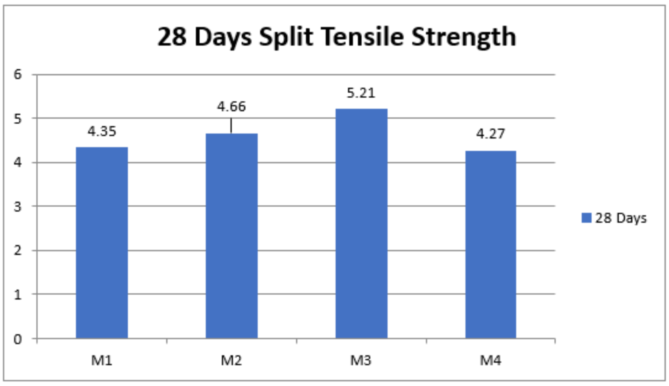


Chart – 6 Split Tensile Strength at 28 Days

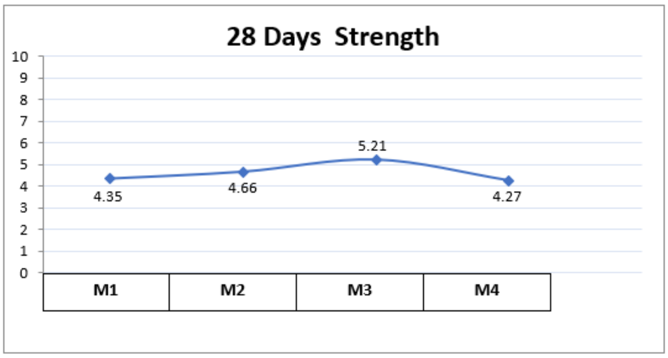


Chart - 7 Split Tensile Strength at 28 Days

6. CONCLUSIONS

i. The consumption of cement and the cost of building both decrease when GGBS is partially replaced with cement.

ii. Workability is improved by the partial replacement of the GGBS with cement.

iii. The optimum percentage obtained at M3 mix proportion and its compressive strength was 54.10 MPa which is 5.4% higher than that of conventional concrete 51.33 MPa at 28 days.

iv. Flexural strength was 8.74 MPa which is 21.56% higher than that of conventional concrete 7.19 MPa at 28 days.

v. And Split tensile strength was 5.21 MPa which is 19.77% higher than that of conventional concrete 4.35 MPa at 28 days.

vi. Compared to conventional concrete, the GGBS concrete decreased the sulphate attack. The amount of slag in the mix decreased the concrete's permeability and made it more difficult for sulphates to enter the concrete.

vii.By using these waste materials in concrete for new projects we can also reduce the emission of CO_2 which is generated while production of Cement in the cement factory which is very dangerous for the environment and reduces the emission of greenhouse gases.

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