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Concrete Mix Design Using GGBS As Partial Replacement Of Cement

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ABSTRACT

Now a days as per the construction part required materials are not Available more. So we Have to Find the another Way by use of the various material instead of coarse Aggregate, fine aggregate, cement in the concrete. Cement is the most expansive constituents of concrete. Over 5% of global carbon dioxide emission is attributed by cement production. In this work alternate source for cement as GGBS is used. A compressive study on properties of concrete when cement is partially replaced by GGBS. GGBS is a by product of from the blast furnace used to make iron. Blast furnaces operate at temperature of about 1500 – 1600 centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestones. It is off white in colour. Percentage replacement of cement with GGBS is replaced at 20%,30% and 40% in a mixture of M30 grade of concrete. The strength such as compressive strength to be found at 7 and 28 days. The strength are compared with normal concrete and optimum % of replacement of GGBS is found out.

Key words : Ordinary Portland cement, GGBS, Compressive strength, Design mix.

KEY WORDS: Cement, Saw dust, Fine aggregate, Compressive Strength.

INTRODUCTION

Concrete is the world's most widely used construction material. The increase in Demand of concrete more the new method and materials are being developed for production of concrete. Concrete is a mixture of cement, water, and aggregates with or without chemical admixtures. The most important part of concrete is cement. Use of cement alone as a binder material produces large heat of hydration. Since the production of this raw material produces lot of CO₂ emission. The carbon dioxide emission from the cement raw material is very harmful to the environmental changes. Nowadays many researchers have been carried out to reduce CO₂. The effective way of reducing CO₂ emission from the cement industry is to use the industrial by products or use of supplementary cementing material such as Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), Silica Fume (SF) and Metakaolin (MK). In this present experimental Work, an attempt is made to replace cement by GGBS to overcome these problems.

OBJECTIVES

1. To use GGBS in concrete by partial replacement of cement.
2. To determine the compressive strength of concrete.
3. To determine the workability of the concrete partial replacing the cement by GGBS.
4. To provide economical construction material.
5. To provide safeguard to the environment by utilizing waste properly

MATERIALS



B) Fine Aggregate

The M sand is used as aggregate confirming to the requirements of IS 2386 (Part-III)-1963 having specific gravity of 2.60 fineness modulus of 5.02 has been used as saying aggregate for this study.

C) Coarse Aggregate



A) Cement

Ordinary Portland cement of 53 grade was used in this study confirming to IS12269-1987 the specific gravity of cement is 3.15 the initial and final setting time were found as 30 minutes and 600 minutes respectively standard consistency of cement wash 30%.



Coarse aggregate obtained from local quarry unit has been used for this study, confirming to IS-2386(Part-III)- 1963 is used maximum size of aggregate used is 20 mm with specific gravity of 2.65

D) GGBS (Ground Granulated Blast Furnace Slag)

Ground granulated blast furnace slag, a co-product produced from blast furnace slag is cooled instantaneously by quenching in large volumes of water to produce Granulated blast furnace slag.



Table -1: Chemical composition of (GGBS)

Content	CaO	Al ₂ O ₃	Fe ₂ O ₃	SiO ₂
GGBS	37.34%	14.42%	1.11%	37.73%

Table -2: Physical properties of (GGBS)

Sr. No.	Test Conducted	Test Results	Requirement as per IS:16714-2018
1	Specific Gravity	2.82	Not Specified
2	Fineness, m ² /kg,	362	Minimum 320
3	Slag Activity	71.0	Not less than 60 percent of control OPC 43 Grade cement mortar cube
	Index (%) 7 days 28 days	89.5	Not less than 75 percent of control OPC43 Grade cement mortar cube

E) Water

The Water used for experiments was portable water confirming as per IS 456:2000.

TEST ON MATERIALS

- TESTS ON CEMENT
 1. Standard consistency of cement
 2. Specific gravity of cement
 3. Fineness of cement
- Tests on fine aggregate
 1. Fineness Modulus of Fine Aggregate
 2. Specific Gravity Of Fine Aggregate
- TESTS ON COARSE AGGREGATE
 1. Specific Gravity Of coarse Aggregate
 2. Flaky and elongation test on coarse aggregate
- I. TESTS ON GGBS
 1. Specific Gravity of GGBS
 2. Fineness of GGBS

OBJECTIVE OF STUDY

1. Check the feasibility of GGBS as a replacement of Cement in the construction of concrete.
2. To cast number of cubes, by replacing Cement with GGBS by 20%,30%,40% and to
3. Compare their property with standard mix M35.
4. Study the behavior of compressive strengths of concrete cubes.
5. Compare the result with conventional normal concrete.
6. To find which percentage replacement is much cost Efficient without affecting its strength.
7. To provide economical construction cost.

METHODOLOGY

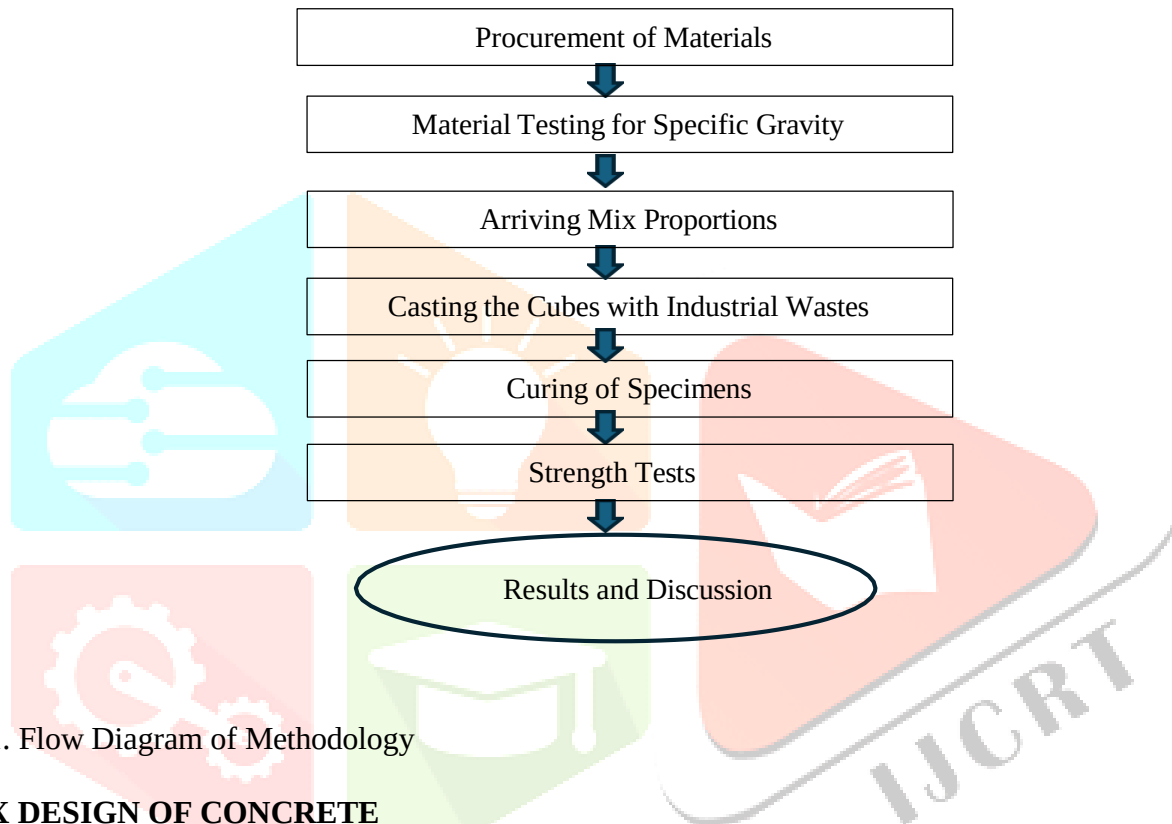


Fig1. Flow Diagram of Methodology

MIX DESIGN OF CONCRETE

Grade of Concrete: M30

Characteristic Strength (f_{ck}): 30 Mpa Standard Deviation: 5 (from IS 10262-2009)

Target Mean Strength: T.M.S. $f_{ck} + 1.65 \times S.D.$ (from IS 456-2000)

$$= 30 + 1.65 \times 5$$

$$= 38.25 \text{ Mpa}$$

Test Data for Material:

Specific Gravity

Cement: 3.15

Coarse Aggregate: 2.88

Fine Aggregate: 2.53 **Water Absorption:**

Coarse Aggregate: 0.5%

Fine Aggregate: 1.0% **Moisture Content** Coarse Aggregate: 0.5% Fine Aggregate: 1.0% **Mix design:**

STEP 1: Target Mean Strength of Concrete (f'_{ck})

$$f'_{ck} = f_{ck} + t_s$$

$$= 30 + 1.65 \times 5$$

$$= 38.25 \text{ MPA}$$

STEP 2: Selection of Water Cement Ratio W/CD 0.45 for concrete grade M35 STEP3: Selection of Water Content

= 186 litre (From IS: 10262 for 20 mm nominal size of aggregates Maximum Water Content 186 Kg/M³) But for desired 100mm slump Water content = $186 + (6/100 \times 186) = 197$ liter

STEP4: Selection Of Cement Content

Hence, Cement Content 197/0.45-437.77 Kg/M³ So, 437.77 Kg/M³ is greater than 340Kg/M

STEP5: Mix Proportion of Fine and Coarse Aggregate:

$1000(1-a_0) \left(\frac{\text{Cement Content}}{\text{Sp. Gr. Of Cement}} + \text{Water Content} + \left(\frac{F}{\text{Sp. Gr.} * P_f} \right) \right) 1000(1-a_0) = \left(\frac{\text{Cement Content}}{\text{Sp. Gr. Of Cement}} + \text{Water Content} + \frac{C}{\text{Sp. Gr.} * P_c} \right)$ Where C, Coarse Aggregate Content

Fa = Fine Aggregate Content

Pf = Sand Content as percentage of total Aggregates

=0.36

Pc = Coarse Aggregate Content as percentage of total Aggregates.

=0.64

a₀ = Percentage air content in concrete (As per IS:10262 for 20 mm nominal size of aggregates air content is 2% = 0.02

Hence, $1000(1 - 0.02) = \left\{ \left(\frac{437.77}{3.15} \right) + 197 + \left(\frac{Fa}{2.53 * 0.37} \right) \right\}$

Fa = 603.02Kg / Cum

As the sand is of Zone II no adjustment is required for sand. Sand Content 603.02 Kg/Cum

$1000(1 - 0.02) = \left\{ \left(\frac{437.77}{3.15} \right) + 197 + \left(\frac{Ca}{2.88 * 0.63} \right) \right\}$

Hence,

Ca = 1170.35Kg / Cum

From combined gradation of Coarse aggregates it has been found out that the proportion of 60:40 of 20 mm & 10 mm aggregates produces the best gradation as per IS: 383.

Hence, 20 mm Aggregates 702.21 kg

And 10 mm Aggregates 468.14 kg

Hence the Mix Proportion becomes:

Table-3 : Mix Proportions

Material	Proportion by Weight	Weight in kg /m ³
Cement	1	437.77
Fine Aggregate	1.42	619.12
Coarse Aggregate 10mm	1.06	468.14
20mm	1.60	702.21
W/C Ratio	0.45	197 liter
Superplasticizer: Sulphonated Naphthalene Formaldehyde 1% of Cementitious Material 4.377 Kg/m ³		

Summary of Concrete Mix Design:

Table 4: Summary of Concrete Mix Design

1	Characteristic Compressive Strength	30 N/mm ²
2	Degree of quality control	Good
3	Standard deviation(S)	5.0
4	Target mean compressive strength, $F_t = F_a + 1.65 * S$	38.25 N/mm ²
5	W/C ratio	0.45
6	Type of cement	OPC
7	Nominal size of coarse aggregate	10 & 20mm
8	Specific gravity of cement, Sc	3.15
9	Specific gravity of fine aggregate, Sa	2.53
10	Specific gravity of coarse aggregate, Sca	2.88
11	Water content per m ³ of concrete	197 Kg/m ³
12	Cement content for W/C=0.45	437.77 Kg/m ³
13	Total fine aggregate per m ³ of concrete, Fa	619.12 Kg/m ³
14	Total coarse aggregate per m ³ of concrete, Ca 10mm 20mm	468.14Kg/m ³ 702.21 Kg/m ³

TESTS & RESULTS

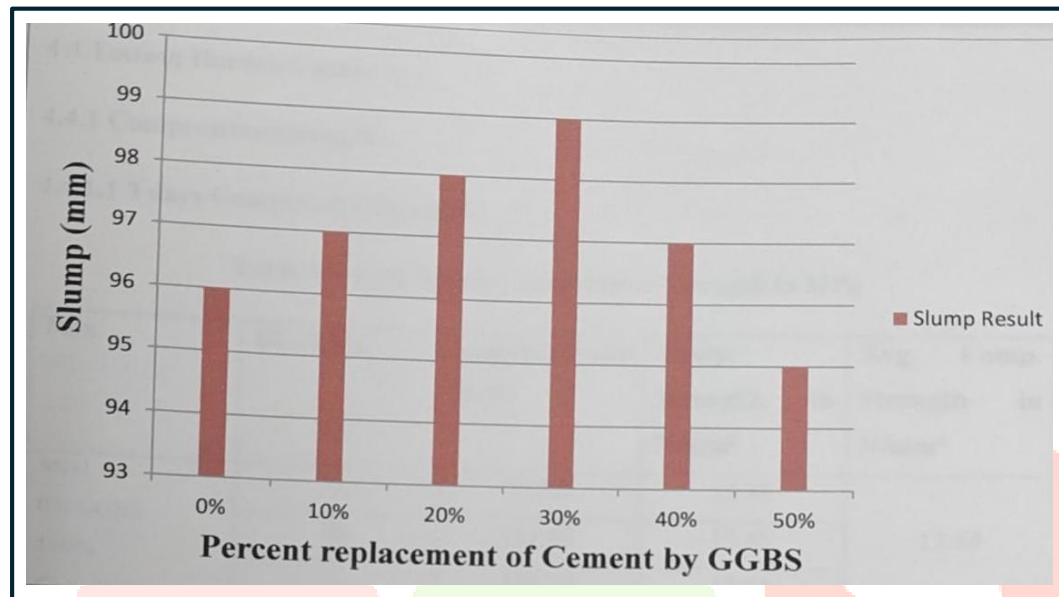
4.3 Tests on Fresh Concrete:

4.3.1 Workability Test:

Slump Cone for Ground Granulated Blast Furnace Slag

Table -5: Slump Result

Sr. no.	%Replacement of GGBS	Slump (mm)
1	0	96
2	10	97
3	20	98
4	30	99
5	40	97
6	50	95



Graph-1: Slump Result vs. % replacement of GGBS Tests on Harden Concrete:

Table 6: Compressive strength on % replacement of GGBS

MIX	AGE (DAYS) IN MPA		
	3 DAYS	7 DAYS	28 DAYS
0%	13.54	27.38	41.71
10%	15.86	29.66	43.60
20%	17.78	31.60	45.65
30%	19.81	33.48	47.82
40%	14.35	30.46	44.61
50%	11.87	26.68	40.26

Table 7: Split tensile strength on % replacement of GGBS

MIX	AGE (DAYS) IN MPA	
	7 DAYS	28 DAYS
0%	1.74	2.86
10%	1.94	3.11
20%	2.96	4.11
30%	3.73	5.46
40%	2.76	5.03
50%	2.49	4.41

Summary - Residue percentage in cement is 2% and standard consistency of cement is 33%. Initial and final setting time in minute are 92 minutes and 376 minutes. Aggregate impact value is 17.42%

and crushing value is 19.53%. Silt content of fine aggregate is 9.44% and bulking of fine aggregate 11.11%. Replacement of GGBS for cement in concrete will increase the compressive strength and split tensile strength of concrete till 30%. After 30% the compressive strength and split tensile strength reduces but even after it is better than 0% replacement. The same result is applicable for workability test on concrete like slump test.

CONCLUSION

Based on the experiments conducted and according to the results obtained, the following are the conclusions that can be drawn:

- Workability of concrete increases with the increase in the GGBS replacement level.
- The compressive strength of concrete is increased for the replacement of GGBS up to 30%.
- Beyond 30% of replacement of GGBS with cement the compressive strength decreases of concrete.
- It is observed that the strength level increases at 20% and 30% replacement of GGBS and falls at 40% replacement for compressive strength.

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