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"Study on Strength of Concrete (M 30 Grade) by Partial Replacement of Cement with Appropriate % of Ground Granulated Blast Furnace Slag (GGBS), Calcium Carbide Residue (CCR) and Fly Ash (FA)"

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Abstract - *In the recent years endeavor has been to develop a green concrete by utilizing industrial waste and reducing emission of carbon di oxide pollution in environment by replacing cement. In the present work it has been explored to use the blended mix of GGBS, CCR and Fly Ash by partial replacement of cement with appropriate % in concrete to develop green concrete. Present study evaluates strength and durability parameters of the concrete containing the combination of above mentioned materials. For durability analysis 5 % H_2SO_4 and 5 % HCL solutions prepared and sample were immersed in acid solution for 28 days, then % change loss in compressive strength with reference to control mix was observed. The experimental program consists of preparing concrete mixes with GGBS as a partial replacement of cement (5%, 10%, 15%, 20%, 25% & 30%) and similarly CCR and Fly ash also used as a partial replacement Cement with the same proportions. On the basis of the results the strength of control mix is well compared to the blend mix which is prepared with 15% GGBS, 5% CCR and 10% Fly ash. Cement was replaced 30% by the combination of cement replacing materials without affecting the strength (hardly variation was observed around 1%).*

***Key Words*:** GGBS, CCR, Control Mix, Strength, Blend Mix

1. INTRODUCTION

Concrete is one of the most versatile and widely accepted construction materials globally. The reason behind this is the naturally, cheaply and easily availability of ingredients as cement, river sand, coarse aggregate and water. As there is no alternative binding material which totally replace the cement so the utilization of partial replacement of cement is well accepted for concrete composites. As a Supplementary cementitious material Ground-granulated blast-furnace slag, fly ash, silica fume, calcium carbide residue can be used.

Present study focus on the durability and strength parameters with partial replacement of cement with some above mentioned materials.

2. EXPERIMENTAL PROGRAMME

2.1 Raw Material Characteristics

Cement: In present experimental study Ordinary Portland Cement of 43 Grade (Ambuja Cement) conforming to IS: 8112 - 1989 was used. The Specific gravity of cement was 3.15.

Fine and Coarse Aggregate: As a fine aggregate natural river sand was used and tested as per IS: 2386 – 1983 brought from Banas, Tonk. Specific gravity of fine aggregate was found to be 2.66. Coarse aggregate was tested as per IS 2386-1983 brought from crusher at Kukas NH8 and the specific gravity of coarse aggregate was found to be 2.70. The fineness Modulus of fine aggregates was 2.55.

Ground-granulated blast-furnace slag (GGBS) – GGBS is obtained by quenching molten iron slag from a blast furnace in water or stream, to produce a glassy, granular product that is then dried and ground into a fine powder.

Calcium Carbide Residue: - CCR is a waste product obtained from the acetylene gas (C_2H_2) production process, as shown in the following equation:

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

Acetylene (C_2H_2) gas is used for welding in construction industries, while the by-product (CCR) is dumped as waste in landfills and create a threat to the environment. For example, in Thailand, as much as 2500 tons of CCR is generated annually.

Fly ash – Fly ash is a wastage product basically generated from the combustion of coal. On behalf of its physical and chemical properties it is widely used in construction activities now days.

Table -1: Chemical composition of material

S. No	Chemical Properties	Cement	GGBS	CCR	FA
1.	CaO	62-67%	30-34%	51.9%	2%
2.	SiO_2	17-25%	30-36%	3.4%	60%
3.	Al_2O_3	3-8%	18-25%	2.6%	30%
4.	Fe_2O_3	3-4%	0.8-3%	0.3%	4%
5.	SO_3	1-3%	0.1-0.4%	0.2%	0.67%
6.	MgO	0.1-3%	6-10%	0.5%	1%

Table -2: Physical composition of material

S. No.	Physical Properties	GGBS	CCR	FA
1.	Specific gravity	2.9	2.1	2.69
2.	Shape texture	Irregular	Non Uniform	Spherical
3.	Color	Grey	White	Grey

2.2 Control Mix: After trial mixes I, II, III the final mix was selected as control mix. Control mix was designed as per IS 10262:2009 specification and recommendation which are given below-

Table -3: Control Mix Proportion for M30 (For 1 Cum. of Concrete)

S. No	Materials	Weight
1.	Cement	391Kg
2.	Coarse aggregate	1177 Kg
3.	Fine aggregate	692 Kg
4.	Water	168 Ltr
5.	Admixture (1 % of cement)	3.5Ltr
6.	W/C Ratio	0.43

2.3 Proportion of different replacing materials

In present study GGBS, CCR and Fly ash used as a partial replacement of cement, the replacement level for GGBS used in present study varies from 5% to 30%, with 5% interval by weight of cement. Similarly the replacement level for CCR and fly ash used in the study varies from 5% to 30%, with 5% interval which is same as GGBS replacement levels.

Table 4 Replacement Level of Materials

S. No	MIX	CEMENT + GGBS (% wise replacement)	CEMENT + Replacing Material (Weight wise replacement)
1.	CONTROL MIX	100 + 0	391 + 0
2.	MIX 1	95 + 5	371.45 + 19.55
3.	MIX 2	90 + 10	351.9 + 39.1
4.	MIX 3	85 + 15	332.35 + 58.65
5.	MIX 4	80 + 20	312.8 + 78.2
6.	MIX 5	75 + 25	293.25 + 97.75
7.	MIX 6	70 + 30	273.7 + 117.3

3. Tests on concrete (Fresh and Hardened State)

The following tests were conducted on concrete.

1. Slump test
2. Compressive Strength
3. Flexural Strength
4. Splitting Tensile Strength

In this study three specimens were tested at 7 days and 28 days. The tests for Compressive strength of cube was performed on CTM (Compression Testing Machine), and flexure strength of beam and splitting tensile strength of Cylinder Test were performed on a UTM (Universal Testing Machine) of capacity 1000 kN.

4. Test Results and Discussions

4.1 Slump

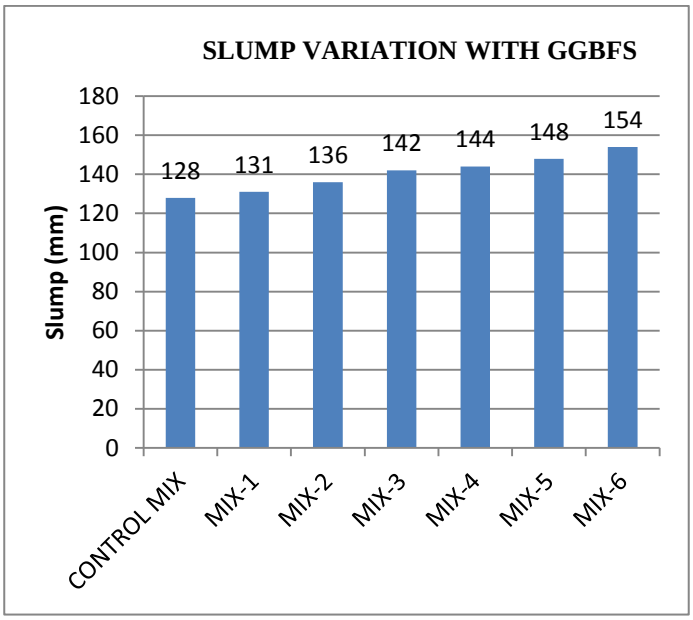

Chart -1: Slump variation with GGBS

There is an increasing trend of slump with the increase of GGBS % in concrete by replacing cement.

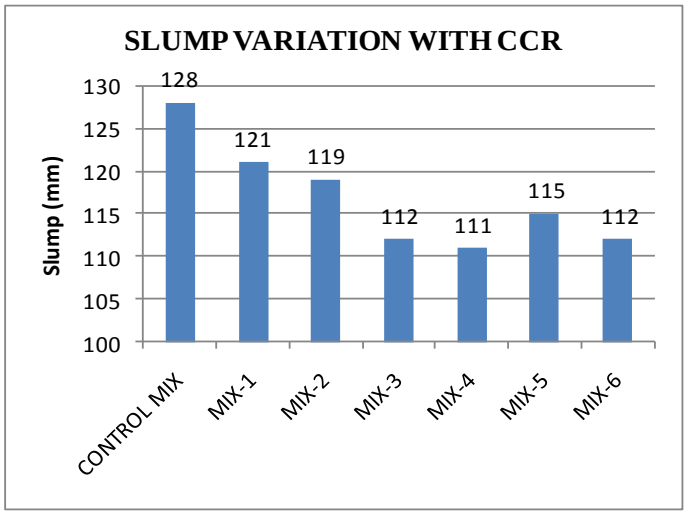

Chart -2: Slump variation with CCR

There is a reducing trend of slump with the increase of CCR % in concrete by replacing cement.

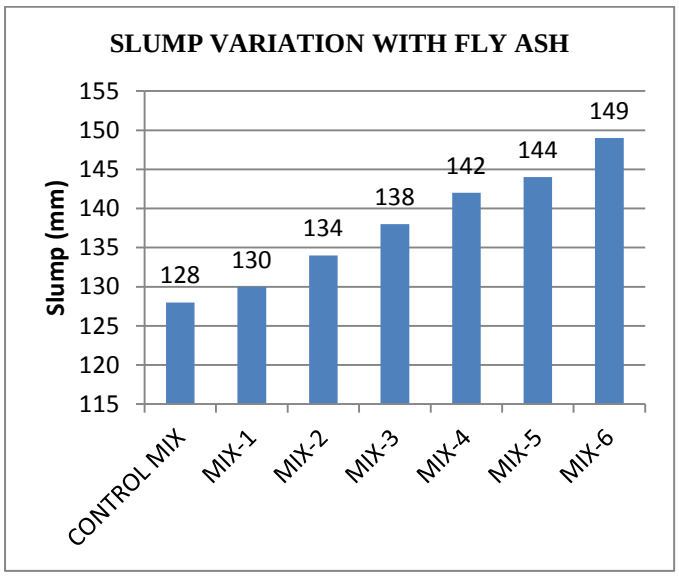

Chart 3 Slump variation with Fly Ash

4.2 Compressive Strength

The Compressive Strength test results of control mix and concrete prepared with replacement of cement by different replacing materials (with 5% to 30 %) at the age of 7 and 28 days are presented below :

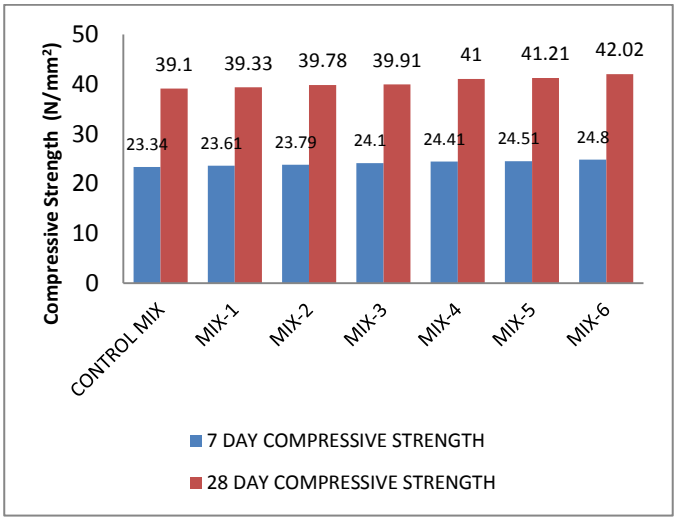

Chart 4 Compressive strength test results with GGBS at 7 days & 28 days

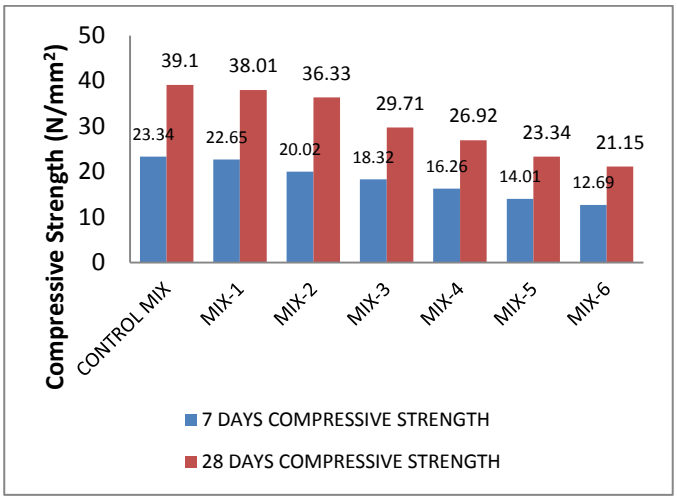

Chart 5 Compressive strength test results with CCR at 7 days & 28 days

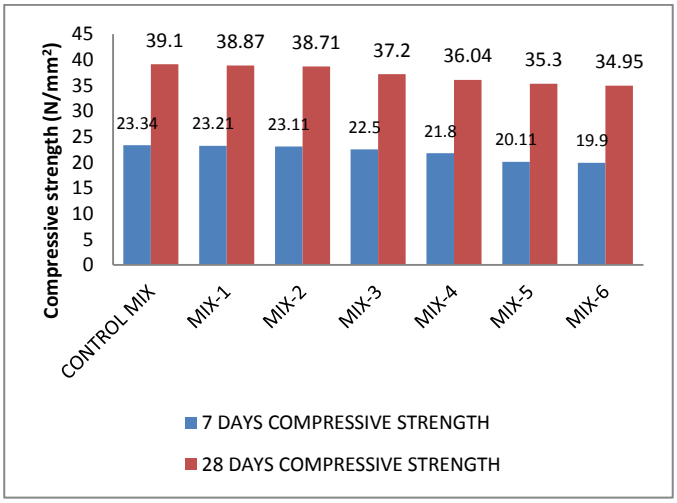

Chart 6 Compressive strength test results with Fly Ash at 7 days & 28 days

4.3 Flexural Strength

The Flexural Strength test results of control mix and concrete prepared with replacement of cement by different replacing materials (with 5% to 30 %) at the age of 7 and 28 days are presented below:

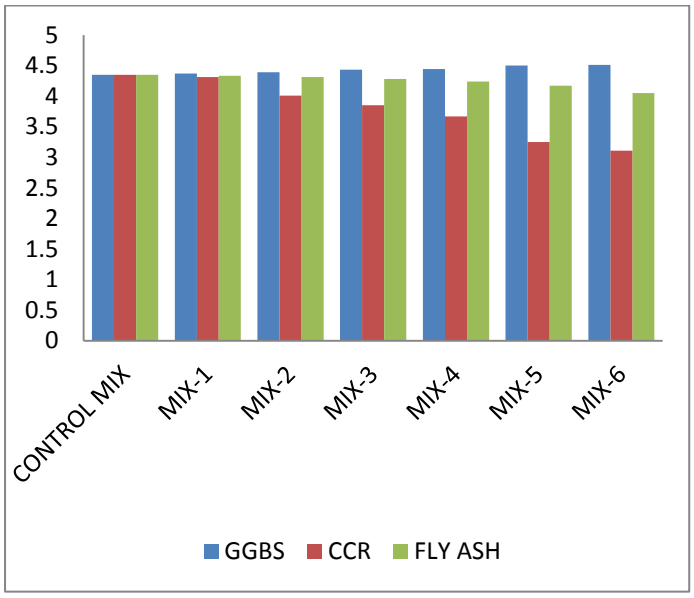

Chart 7 Flexural strength test results at 28 days

4.5 Split Tensile Strength Test

The split Tensile Strength test results of control mix and concrete prepared with replacement of cement by different replacing materials (with 5% to 30 %) at the age of 7 and 28 days are presented below:

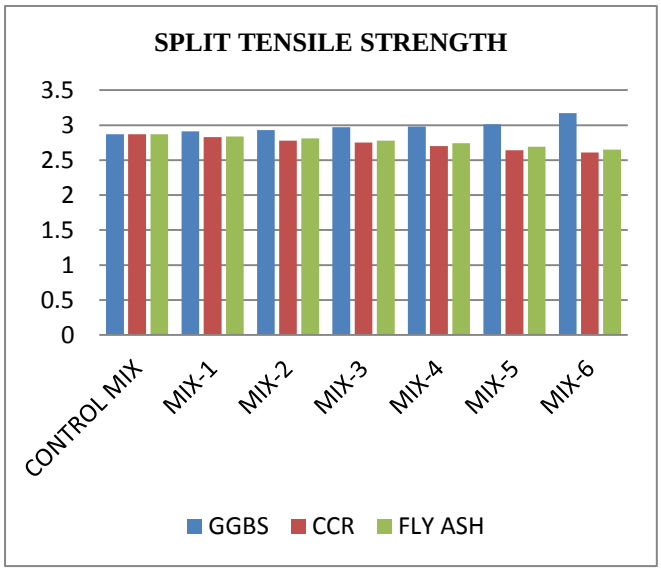

Chart 8 Flexural strength test results at 28 days

4.6 Test Result for Blended Mix

4.6.1 After taking the observations with different replacing material and different replacement levels, some values of the strength were observed that was quite similar (satisfactory results) to the strength of mix prepared without any replacement. On behalf of those values a blend mix also prepared. The combination of blend mix represent in table below:

Table 5 Replacement Level of Materials in Blend Mix

MIX	CEMENT	GGBS	CCR	FLY ASH
BLEND MIX	70%	15%	5%	10%

4.6.2 Compressive strength of blend mix prepared with 15% GGBS, 5% CCR and 10% fly ash is shown in table:

Table 6 Compressive strength of Blend Mix at 28 days

MIX	COMPRESSIVE STRENGTH (N/mm²)
BLEND MIX (70%Cement +15% GGBS +10% F.A.+5% CCR)	38.89
CONTROL MIX	39.10

4.6.3 Flexural strength of blend mix prepared with 15% GGBS, 5% CCR and 10% fly ash is shown in table:

Table 7 Flexural strength of Blend Mix at 28 days

MIX	FLEXURAL STRENGTH (N/mm²)
BLEND MIX (70%Cement +15% GGBS +10% F.A.+5% CCR)	4.19
CONTROL MIX	4.21

4.6.3 Split Tensile strength of blend mix prepared with 15% GGBS, 5% CCR and 10% fly ash is shown in table:

Table 8 Compressive strength of Blend Mix at 28 days

MIX	SPLIT TENSILE STRENGTH (N/mm²)
BLEND MIX (70%Cement +15% GGBS +10% F.A.+5% CCR)	2.8
CONTROL MIX	2.87

5. CONCLUSIONS

- Slump value of concrete mix increases with addition of GGBS and Fly Ash but It decreases with addition of CCR content.
- In the mixes with GGBS (varies from 5% to 30% as a cement replacement by weight) the compressive strength gives satisfactory results for all the ages (7 and 28 days) Compressive strength for the mix with 30% replacement level is around 7% more than the compressive strength of control mix
- Compressive strength of concrete mix for 5% replacement level with CCR was approximately same to the target mean strength of control mix. For more than 5% replacement of CCR compressive strength of mix start decreasing and for 30 % replacement it was reduced by 45% in comparison of control mix at 28 days.
- With the replacement of Fly ash up to 10% the compressive strength of concrete was slightly reduced (approx 1%) to the control mix. But for more than 10% replacement level the reduction in strength noticed and for 30% replacement level compressive strength of mix reduced around 11% in comparison to of control mix at 28 days, as considering the economical aspects 5% to 10% replacement of cement by fly ash can be acceptable.
- Compressive strength, flexure strength and split tensile strength of blended mix at the age of 28 days was observed almost same to the control.
- Thus it is concluded that a suitable blended green concrete of M30 grade by replacing cement with 15% GGBS, 10 % Fly Ash & 5% CCR could be developed having the same mechanical properties.

6. FUTURE SCOPE

- Study on FRC with blended mix using appropriate % of GGBS. Fly Ash & CCR replacing cement can be carried out for higher grade durable concrete.
- Study on Self Compacting Concrete using appropriate % of GGBS, Fly Ash & CCR replacing cement be carried out on special concrete.
- Study on use of Silica Fume & CCR replacing cement in concrete be carried out for higher grade of concrete such as M50 for high rise buildings.
- Study on the crusher sand by replacing sand along with the partially replacing cement with GGBS, CCR & Fly Ash.
- Study on recycled aggregates & partial replacement of cement by GGBS, CCR & Fly Ash in concrete.

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