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Estimation Of Strength Properties Of Binary And Ternary Blend Concrete By Experimental And Analytical Tools

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***Abstract:** In this work residual compressive strength and tensile strengths of ternary and binary blend concrete when subjected to elevated temperatures of 32^{0}C 200^{0}C 400^{0}C and 600^{0}C were investigated. Three mixes in which one was control mix having no admixtures and two mixes were binary blend concrete having 20% RHA and 30% GGBS were prepared. One more mix of ternary blend concrete consisting of 20%RHA and 30%GGBS. M Sand was used in all these mixes as fine aggregate.Multiple linear regression analysis was also carried out. Non-Destructive testing methods VIZ Rebound Hammer and Ultrasonic Pulse Velocity tests were also conducted to study the deviation in the results. Results of these experimental and analytical investigations reveal that use of M Sand dramatically improve the target strength (Predicted by using IS Code). Binary blend concrete containing 30% GGBS as cement replacement material outperforms all other admixture combinations at all the temperatures considered. Experiments also indicate that binary blend containing 20% RHA as cement replacement material is not suitable when concrete is exposed to elevated temperatures*

***Keywords:** Compressive strength, Tensile strength, NDT, GGBS, Rice husk ash, Regression analysis*

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I. INTRODUCTION

Concrete is the maximum notably and broadly used constructing ingredient for construction everywhere in the world. Concrete can be produced by means of regionally accessible ingredients, extensive type of structural configurations can be casted using concrete, and it requires minimal protection for the duration of entire carrier life . The production of each one tone of Portland cement, releases the identical amount of carbon dioxide into the surroundings. For this purpose pozzolanic materials are incorporating in to concrete like Fly ash, Silica, GGBS and many others the ones are called as supplementary cementitious substances (SCM's). Incorporation of these SCM's not simplest enhance the homes of concrete additionally they reduces the cement content in concrete. The discount of cement content method it decrease the environment affects prompted in cement production manner and maximum of those materials are business with the aid of-products, troubles with disposal additionally may be solved.

II. MATERIAL AND METHODOLOGY

A. MATERIALS

The OPC 43 Grade cement of Ultra-Tech has been used in the experimental work. Manufactured sand of specific gravity 2.6, Coarse aggregates used in the project work are of 20 mm down size and have specific gravity of 3. Conplast SP430 is a chloride free super plasticizing admixture which is brown in color and dispersible in water. Rice husk ash of density is 0.78 g/cc and specific gravity of 2.1 used. Ground Granulated Blast furnace slag of specific gravity was 2.81 .The properties of Cement, GGBS and RHA are represented in Table 1 , 2 and 3 respectively.

Property	Value	Standard values (IS 8112 : 1989)
Specific gravity	3.15	Not specified
Fineness (%)	268m^2/kg	225m^2/kg
Normal or Standard consistency (%)	36	Not specified
Initial setting time (minutes)	155	30 (min)
Final setting time (minutes)	265	600 (max)
Soundness (Le chatelier method) (mm)	4	10 (max)

Table 1: Physical Properties Of Cement

Constituents	(% wt)
SiO_2	40
Al_2O_3	13.5
Fe_2O_3	1.8
CaO	39.2
MgO	3.6
LOI	0.0
SO_3	0.2
K_2O	0.2
Na_2O_3	Nil

Table 2: Properties Of GGBS

Grain Size	0-2 mm
Color	Grey
Moisture (%)	Max 1 %
Bulk Density	180-230 kg/m3
Form	Amorphous

Table 3: Properties Of RHA

B. MIX PROPORTIONING

In the present investigation four different mixes were prepared. The mix design for control mix was done using IS 10262:2009 and the mix proportion obtained was 1:1.46:2.88 to produce M30 concrete at a constant w/c of 0.42.Mix proportions for mixes were adopted are as shown in Table 4.

Mix ID	Cement kg/m^3	M-sand kg/m^3	Coarse aggregate kg/m^3	GGBS kg/m3	RHA kg/m3
#CM	410.6	601.25	1182.8	0	0
#RHA(20%)	328.48	601.25	1182.8	0	82.12
#GGBS(30%)	287.42	601.25	1182.8	123.18	0
#RG	205.3	601.25	1182.8	123.18	82.12

Table 4: Mix Proportioning per m^3 of Concrete

C. MIXING PROCEDURE

First cement, M-Sand and Coarse aggregates were dry mixed. Admixtures were added to the batch in dry state as per the mixes. Then small quantity of water was added to make concrete paste and remaining quantity of water was added with super plasticizer. Mixing is done till paste become uniform.

D. CASTING AND CURING

The casting of specimens was done as soon as mixing was over. The concrete was filled in three layers in the cubes mould as well as in the cylinder mould. To remove the entrapped air in the concrete proper compaction was carried out.For better compaction specimen were kept on Vibration table. Second day, moulds were de-molded and specimens were taken out for curing. The curing of specimens was done by normal water curing for 28 days. Next day these specimens were heated at higher temperature and brought back to normal temperature by air cooling.

E. TESTING

Concrete cubes of 15 cm * 15 cm *15 cm were casted and Concrete cylinders of 150 mm Ø and 300 mm height were casted and they are tested on Compression testing machine. Non destructive tests using Rebound hammer and Ultra-sonic pulse velocity machine were conducted before crushing.

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III. EXPERIMENTAL RESULTS AND DISCUSSION

A. COMPRESSIVE STRENGTH

Compressive strength test results for all four mixes at different temperatures is presented in Table 5. Figure 1 shows the variation in compressive strength of different mixes at different temperatures. From Fig. 1 shows Variation of Compressive strength at different temperatures, it is observed that in case of binary mix containing 30% of GGBS, the performance is more satisfactory when compared with all other mixes including the control mix.

MIX ID	Temperature	Compressive strength
#CM	32	48.5
	200	48.85
	400	52.5
	600	44.74
#RHA	32	41.48
	200	33.79
	400	43.7
	600	25.93
#GGBS	32	53.5
	200	54.07
	400	58.05
	600	52
#RG	32	43
	200	38.22
	400	44.44
	600	30.37

Table 5: Compressive strength of all mixes at different temperatures

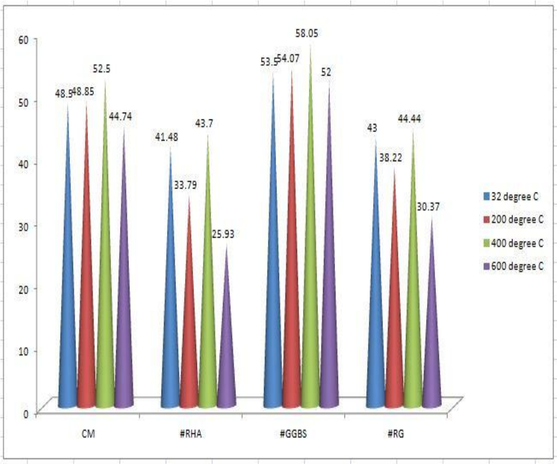

Figure 1: Variation of Compressive strength(MPa) at different temperature

B. SPLIT TENSILE STRENGTH

Split Tensile strength test results for all four mixes at different temperatures is presented in Table 6. Figure 2 shows the variation in tensile strength of different mixes at different temperatures. From Fig. 2 shows Variation of Tensile strength at different temperatures, it is observed that in case of binary mix containing 30% of GGBS, the performance is more satisfactory when compared with all other mixes including the control mix.

MIX ID	Temperature	Split Tensile strength
#CM	32	4.7
	200	4.02
	400	3.91
	600	1.75
#RHA	32	4.19
	200	4
	400	3.04
	600	1.34
#GGBS	32	4.78
	200	4.53
	400	3.89
	600	2.38
#RG	32	4.95
	200	3.45
	400	3.39
	600	1.17

Table 6: Split Tensile strength of all mixes at different temperatures

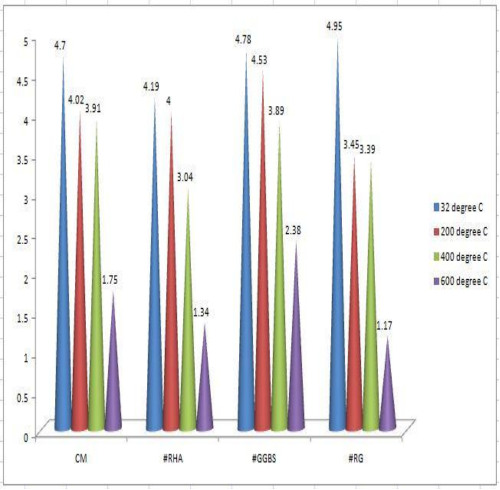

Figure 2: Variation of Split Tensile strength(MPa) at different temperature

C. NON-DESTRUCTIVE TEST

The Rebound Hammer test is conducted as per IS 13311-part 2,1992 .The rebound number is noted down by pressing it on the surface and compressive strength in N/mm^2 is calibrated using Schmidt chart.

Ultra Sonic Pulse Velocity test is a qualitative Non-destructive test .The test is conducted as per IS 13311-part 2,1992 and the readings are obtained in km/sec .Then we can predict the quality of concrete using chart given in IS code. The Results of Rebound Hammer and Ultrasonic Pulse Velocity conducted on concrete specimens are tabled below.

MIX ID	Temperature	Compressive strength	RBH	UPV	Remark
#CM	32	48.5	38.8	5.02	Excellent
	200	48.85	41.1	4.26	Good
	400	52.5	42	3.44	Medium
	600	44.74	35.8	2.33	Doubtful
#RHA	32	41.48	33.2	4.19	Good
	200	33.79	27	3.5	Good
	400	43.7	35	1.4	Doubtful
	600	25.93	19.4	0.39	Doubtful
#GGBS	32	53.5	42.5	4.88	Excellent
	200	54.07	42.5	4.2	Good
	400	58.05	44.3	3.71	Good
	600	52	41.9	1.67	Doubtful
#RG	32	43	34.4	4	Good
	200	38.22	30.6	3.59	Good
	400	44.44	34.8	2.47	Doubtful
	600	30.37	24.3	0.25	Doubtful

Table 7: Non Destructive Test Results

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IV. REGRESSION ANALYSIS

For statistical analyses, multivariable linear regression analysis (MRA) was employed. The purpose of MRA is to simultaneously identify two or more independent variables that explain variations in the dependent variable. The general MRA equation is given below, with the dependent variable being a linear function of more than one independent variable. For prediction of the compressive strength of admixture concrete before production, compressive strength is considered as a dependent variable, while the proportions of cement, RHA, GGBS and Temperature are independent variables. The generalized equation obtained is given below

f_{ck}= 66.66 - (CEMENT*0.03466) - (RHA*0.20405) - (GGBS*0.025) - (T *-0.00995)

Where, f_{ck} = Compressive strength in N/mm^2

RHA= Rice Husk Ash in kg

GGBS = Ground granulated blast furnace slag in kg

T = Temperature in degrees

The predicted strengths of all mixes at different temperatures are presented in table 7 and the variation of residual strength i.e difference between experimental and predicted values is presented in figure 3.

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Observations	Cement	RHA	GGBS	Temp	Compressive strength	Predicted Compressive Strength	Residual
1	410.6	0	0	32	48.5	52.23	-3.73
2	328.48	82.12	0	32	41.48	38.32	3.16
3	287.42	0	123.18	32	53.5	53.42	0.08
4	205.3	82.12	123.18	32	43	39.51	3.49
5	410.6	0	0	200	48.85	50.44	-1.59
6	328.48	82.12	0	200	33.79	36.53	-2.74
7	287.42	0	123.18	200	54.07	51.63	2.44
8	205.3	82.12	123.18	200	38.22	37.72	0.50
9	410.6	0	0	400	52.5	48.45	4.05
10	328.48	82.12	0	400	43.7	34.54	9.16
11	287.42	0	123.18	400	58.05	49.64	8.41
12	205.3	82.12	123.18	400	44.44	35.73	8.71
13	410.6	0	0	600	44.74	46.46	-1.72
14	328.48	82.12	0	600	25.93	32.55	-6.62
15	287.42	0	123.18	600	52	47.65	4.35
16	205.3	82.12	123.18	600	30.37	33.74	-3.37

Table 8: Predicted strengths of all mixes at different temperatures

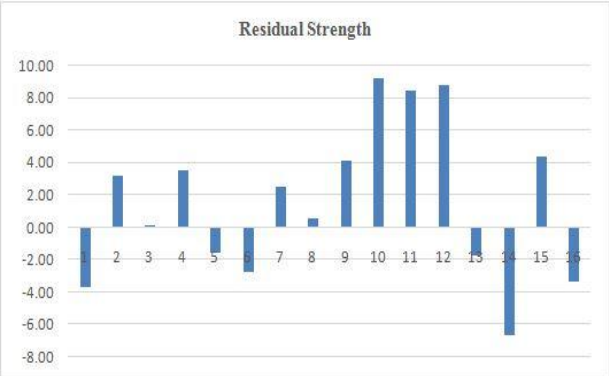

Figure 3: Variation of Residual Strength of all mixes

V. CONCLUSIONS

The following conclusions are drawn from the study,

- ✓ At normal temperature, mix containing 30% GGBS has performed better than other mixes (including the control mix) both in compression and tension". Increased compressive strength is due to GGBS and manufactured sand.
- ✓ When all these mixes are subjected to an elevated temperature of 200°C, 400°C, 600°C for 2 hours, compressive strength increase, but there is a decline in tensile strength. Tensile strength marginally reduces in all the mixes compared to control mix. Here also concrete containing 30% GGBS has performed better in compression than other mixes at 400 °C.

Validation of experimental data was statistically done using multivariable linear regression analysis (MRA) in EXCEL 2016 version .Satisfactory values of correlation coefficient (R) and determination coefficient (R^2) were obtained.

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