

AN EXPERIMENTAL STUDY ON CONCRETE CONTAINING GGBFS AND META KAOLIN WITH CALCIUM CARBIDE RESIDUE

Amit Saini¹, Shivanshi², Ankush kumar Jain³

¹M.tech Scholar Dept. of Civil Engineering, School of Engineering and Technology Poornima University, Jaipur, Rajasthan,

^{2,3}Assistant Professor, Dept. of Civil Engineering, School of Engineering and Technology Poornima University, Jaipur, Rajasthan, India

Abstract - In recent years, some investigations are reported on Ground-granulated blast-furnace slag and Meta kaolin individually. The study reported in the report presents experimental work on combined use of Ground-granulated blast-furnace slag and Calcium Carbide Residue and with Meta kaolin and Calcium Carbide Residue in concrete and showing the comparison at various replacement levels and at various ages. Grade of concrete pick for present study is M-40. The objective of the present study is to determine strength parameters of the concrete containing GGBFS and Meta kaolin with Calcium Carbide Residue. The experimental program consists of preparing concrete mixes with GGBFS and Meta kaolin as a partial replacement of cement (5%, 10% & 15%) and Calcium Carbide Residue partially replaced with sand (5% & 10%). The performance of the concrete mixes for compressive strength at various ages, compressive strength with acid curing, flexural was investigated.

Key Words: GGBFS, Meta kaolin, Calcium Carbide Residue, Compressive strength, Flexural strength.

1. INTRODUCTION

The present study basically focuses on two major problems and tries to solve them. First is to save the environment from the harmful gases or pollutants coming out from the production of construction materials such as cement and second is high cost of construction because of high cost of cement. Throughout the world concrete is one of the most demanding material and to full fill the demand of cement a huge number of companies or factories started production of cement. According to some literatures the 1 tons of carbon dioxide is estimated to be released to the atmosphere when 1 tone of ordinary Portland cement is manufactured, so it is essential to control the production rate of cement. So to overcome this problem it is essential to find the alternatives which can be used in place of cement fully or partially. But still no alternative binding material found which totally replace the cement so the utilization of partial replacement of cement is well accepted for concrete composites. As a Supplementary cementations material Ground-granulated blast-furnace slag, fly ash, meta kaolin, silica fume can be used. The rapid construction in the world, need more construction materials. However some problems associated with this rapid construction activities is that it is responsible

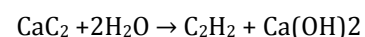
for approximately 40% natural resources consumption. Due to this rapid consumption natural resources like sand also need an alternative. In Present study CCR used as a partial replacement of sand.

2. Raw Materials Characteristics

Meta kaolin is not a by-product. It is obtained by the calcinations of pure or refined Kaolinite clay at a temperature between 6500 C and 8500 C, followed by grinding to achieve a finesse of 700-900 m²/kg. Metakaolin is a pozzolanic additive/product which can provide many specific features. Meta kaolin is available in many different varieties and qualities. The purity will define the binding capacity or free lime.. When used in concrete it will fill the void space between cement particles resulting in a more impermeable concrete. Meta kaolin, is a relatively new material in the concrete industry, is effective in increasing strength.

GGBFS 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. GGBS is used to make durable concrete structures in combination with ordinary Portland cement or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia for its superiority in concrete durability, extending the life span of buildings from fifty to a hundred years. GGBS reacts like Portland cement when in contact with water. The mineral admixture used for this experimental work is Ground-granulated blast-furnace slag

Calcium Carbide Residue :- CCR is a by-product obtained from the acetylene gas (C₂H₂) production process, as shown in the following equation:



Acetylene (C₂H₂) gas is widely used for ripening fruit in agriculture and for welding in industry, while the by-product (CCR) is often discarded as waste in landfills and thus poses a threat to the environment. For example, in China, as much as 2500 tons of CCR is generated annually. CCR is highly alkaline in nature and it is mainly composed of calcium hydroxide with a mass fraction of above 92%. Various

literatures stated that, mixing CCR with certain pozzolans, which have high silicon dioxide or aluminium oxide content, could yield pozzolanic reactions, resulting in final products that are similar to those obtained from the cement hydration process.

Super plasticizer - Super plasticizer (Sika-Plastiment) was used @ 1% of weight of cement. Specific gravity of Sika-Plastiment is 1.12 (as per manufacturer).

3. CONTROL MIX

Control mix was designed as per IS 10262:2009. Typical Computations are given below:

Table -1: Control mix

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)	3.15 Ltr
6.	W/C Ratio	0.43

4. RESULTS

4.1 The Slump test results of control mix and concrete prepared with 5%, 10% and 15%, replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively are presented in Table 1 and Table 2

Table -2: Slump Variation with GGBFS

OPC	GGBFS	Slump (mm)
100	0	63
95	5	65
90	10	67
85	15	69

Table -3: Slump Variation with Meta kaolin

OPC	METAKAOLIN	Slump (mm)
100	0	63
95	5	64
90	10	66
85	15	67

4.2 Compressive strength

The comparison of Compressive Strength test results of control mix and concrete prepared with 5% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 are presented in Table 4

Table 4 Comparison in Compressive Strength with 5% GGBFS and 5% Meta kaolin at the age of 28 days

OPC + GGBFS/MK	Sand + CCR	Compressive Strength (N/mm ²)	
		28 DAYS (GGBFS)	28 DAYS (MK)
100+0 (CM)	100+0	48.23	48.23
95+5	100+0	49.01	49.71
	95+5	48.12	48.21
	90+10	47.56	48.04

The comparison of Compressive Strength test results of control mix and concrete prepared with 10% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 are presented in Table 5

Table 5 Comparison in Compressive Strength with 10% GGBFS and 10% Meta kaolin at the age of 28 days

OPC + GGBFS/MK	Sand + CCR	Compressive Strength (N/mm ²)	
		28 DAYS (GGBFS)	28 DAYS (MK)
100+0 (CM)	100+0	48.23	48.23
90+10	100+0	49.73	50.37
	95+5	48.65	49.55
	90+10	47.89	48.9

The comparison of Compressive Strength test results of control mix and concrete prepared with 15% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 are presented in Table 6

Table 6 Comparison in Compressive Strength with 15% GGBFS and 15% Meta kaolin at the age of 28 days

OPC + GGBFS/MK	Sand + CCR	Compressive Strength (N/mm ²)	
		28 DAYS (GGBFS)	28 DAYS (MK)
100+0 (CM)	100+0	48.23	48.23
85+15	100+0	50.01	49.32
	95+5	49.21	48.74
	90+10	48.34	47.13

4.3 Flexural strength

The comparison of Flexural Strength test results of control mix and concrete prepared with 5% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 are presented in Table 7

Table 7 Comparison in Flexural Strength with 5% GGBFS and 5% Meta kaolin at the age of 28 days

OPC + GGBFS/MK	Sand + CCR	Flexural Strength (N/mm ²)	
		28 DAYS (GGBFS)	28 DAYS (MK)
100+0 (CM)	100+0	4.89	4.89
95+5	100+0	4.92	4.91
	95+5	4.87	4.88
	90+10	4.84	4.86

The comparison of Flexural Strength test results of control mix and concrete prepared with 10% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 are presented in Table 8

Table 8 Comparison in Flexural Strength with 10% GGBFS and 10% Meta kaolin at the age of 28 days

OPC + GGBFS/MK	Sand + CCR	Flexural Strength (N/mm ²)	
		28 DAYS (GGBFS)	28 DAYS (MK)
100+0 (CM)	100+0	4.89	4.89
90+10	100+0	4.96	4.97
	95+5	4.91	4.94
	90+10	4.88	4.91

The comparison of Flexural Strength test results of control mix and concrete prepared with 15% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 are presented in Table 9

Table 9 Comparison in Flexural Strength with 15% GGBFS and 15% Meta kaolin at the age of 28 days

OPC + GGBFS/MK	Sand + CCR	Flexural Strength (N/mm ²)	
		28 DAYS (GGBFS)	28 DAYS (MK)
100+0 (CM)	100+0	4.89	4.89
85+15	100+0	4.99	4.93
	95+5	4.94	4.90
	90+10	4.9	4.85

4.4 Comparison in Compressive Strength with Acid Cured Specimen

The comparison of Compressive Strength test results of control mix and concrete prepared with 5% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 with water curing and with Acid curing respectively are presented in Table 10

Table 10 Comparison in Compressive Strength with 5% GGBFS and 5% Meta kaolin at the age of 28 days Acid Curing

OPC + GGBFS/MK	Sand + CCR	Compressive Strength (N/mm ²)			
		28 DAYS (GGBFS)		28 DAYS (MK)	
		Water curing	Acid Curing (5% HCl)	Water curing	Acid Curing (5% HCl)
100+0 (CM)	100+0	48.23	44.13	48.23	44.13
95+5	100+0	49.01	45.45	49.71	45.8
	95+5	48.12	44.01	48.21	44.23
	90+10	47.56	43.45	48.04	43.9

The comparison of Compressive Strength test results of control mix and concrete prepared with 10% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 with water curing and with Acid curing respectively are presented in Table 11

Table 11

Comparison in Compressive Strength with 10% GGBFS and 10% Meta kaolin at the age of 28 days Acid Curing

OPC + GGBFS/MK	Sand + CCR	Compressive Strength (N/mm ²)			
		28 DAYS (GGBFS)		28 DAYS (MK)	
		Water curing	Acid Curing (5% HCl)	Water curing	Acid Curing (5% HCl)
100+0 (CM)	100+0	48.23	44.13	48.23	44.13
90+10	100+0	49.73	46.02	50.37	45.24
	95+5	48.65	45.22	49.55	45.32
	90+10	47.89	44.2	48.9	44.54

The comparison of Compressive Strength test results of control mix and concrete prepared with 15% replacement of cement by Ground granulated blast-furnace slag and Meta kaolin respectively and the fine aggregate partially replaced by Calcium Carbide Residue in the range of 5% and 10% at the age of 28 with water curing and with Acid curing respectively are presented in Table 11

Table 11 - Comparison in Compressive Strength with 15% GGBFS and 15% Meta kaolin at the age of 28 days Acid Curing

OPC + GGBFS/MK	Sand + CCR	Compressive Strength (N/mm ²)			
		28 DAYS (GGBFS)		28 DAYS (MK)	
		Water curing	Acid Curing (5% HCl)	Water curing	Acid Curing (5% HCl)
100+0 (CM)	100+0	48.23	44.13	48.23	44.13
85+15	100+0	50.01	46.35	49.32	46.12
	95+5	49.21	47.65	48.74	46.92
	90+10	48.34	45.21	47.13	46.11

3. CONCLUSIONS

Slump Values - The Value of slump increases with increase of GGBFS and Meta kaolin content in the mix

Compressive Strength

The mix prepared with 5% Cement replaced by GGBFS and fine aggregate replaced by Calcium Carbide residue 5% and

10% respectively, similarly the mix prepared with 5% Cement replaced by Meta kaolin and fine aggregate replaced by Calcium Carbide residue 5% and 10%, then the strength achieved with Meta kaolin mix were observed 0.15% to 1% higher than the mix with GGBFS at the age 28 days respectively.

The mix prepared with 10% Cement replaced by GGBFS and fine aggregate replaced by Calcium Carbide residue 5% and 10% respectively, similarly the mix prepared with 10% Cement replaced by Meta kaolin and fine aggregate replaced by Calcium Carbide residue 5% and 10%, then the strength achieved with Meta kaolin mix were observed 1.8% to 2% higher than the mix with GGBFS at the age of 28 days respectively.

The mix prepared with 15% Cement replaced by GGBFS and fine aggregate replaced by Calcium Carbide residue 5% and 10% respectively, similarly the mix prepared with 15% Cement replaced by Meta kaolin and fine aggregate replaced by Calcium Carbide residue 5% and 10%, then the strength achieved with GGBFS mix were observed 3 % to 4.2% higher than the mix with Meta kaolin at the age of 28 days respectively.

Flexural strength

The mix prepared with 5% Cement replaced by GGBFS and fine aggregate replaced by Calcium Carbide residue 5% and 10% respectively, similarly the mix prepared with 5% Cement replaced by Meta kaolin and fine aggregate replaced by Calcium Carbide residue 5% and 10%, then the Flexural strength achieved with Meta kaolin mix were observed 0.2% to 0.4% higher than the mix with GGBFS at the age of 28 days respectively.

The mix prepared with 10% Cement replaced by GGBFS and fine aggregate replaced by Calcium Carbide residue 5% and 10% respectively, similarly the mix prepared with 10% Cement replaced by Meta kaolin and fine aggregate replaced by Calcium Carbide residue 5% and 10%, then the Flexural strength achieved with Meta kaolin mix were observed 0.5% to 0.6% higher than the mix with GGBFS at the age of 28 days respectively.

The mix prepared with 15% Cement replaced by GGBFS and fine aggregate replaced by Calcium Carbide residue 5% and 10% respectively, similarly the mix prepared with 15% Cement replaced by Meta kaolin and fine aggregate replaced by Calcium Carbide residue 5% and 10%, then the Flexural strength achieved with Meta kaolin mix were observed 0.8% to 1% higher than the mix with GGBFS at the age of 28 days respectively.

Durability

The compressive strength of concrete prepared with GGBFS, Meta kaolin and CCR are affected with the solution of 5% HCl when the compressive strength results with water curing

compared to those specimen with Acid Curing at the age of 28 days then there was reduction of Compressive strength observed 8% to 2% for the GGBFS and Meta kaolin mix at the age of 28 days, higher content of both the materials (15% replacement) with CCR shows lesser decrement in compressive strength comparatively.

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