An Experimental Investigation on Concrete Containing Ground Granulated Blast Furnace Slag and Kota Stone Powder Slurry

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Abstract - *The study reported in the paper presents experimental work on combined use of Ground-granulated blast-furnace slag and Kota stone powder slurry in concrete. The objective of the present study is to determine strength parameters of the concrete containing GGBFS and Kota stone powder slurry. The experimental program consists of preparing concrete mixes with GGBFS as a partial replacement of cement (20%, 30% & 40%) and Kota stone powder slurry partially replaced with sand (10%, 15% & 20%). The performance of the concrete mixes for compressive strength at various ages and flexural strength was investigated.*

Key Words: *Ground-granulated blast-furnace slag, Kota stone powder slurry, Compressive strength, Flexural strength, Split tensile strength*.

1. INTRODUCTION

India is the largest producer of raw stone materials in the world after China and Italy. During the processing of Cutting, finishing and polishing of stones a large amount of waste in the form of stone slurry and powder is generated. This stone dust is settled by sedimentation and then dumped away which results in environmental pollution therefore utilization of the stone dust in various industrial sectors, especially, the construction would help to protect the environment. Stone waste can be used as a partial replacement of fine aggregate and as a supplementary ingredient to achieve some desired properties of concrete. As Kota Stone is a fine-grained variety of limestone, due to its fineness this stone slurry can be used as a filler material to fill up the voids between the sand grains which provide better durability results, enhance the impermeability of concrete and Chloride ion penetration by formation of dense microstructure. Cement is also one of the mostly used materials in the world. This rapid production of cement creates environmental problems for which we have to find out Civil engineering solutions. Approximately 0.9 ton of carbon dioxide is released to the atmosphere when one tone of ordinary Portland cement is manufactured. 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 can be used and also enhance the properties of concrete in fresh and hydrated states. Ground-granulated blast-furnace slag can also be utilized as a high range water reducer to improve compressive strength or workability. Ground-granulated blast-furnace slag is known to produce a high strength concrete and is used as a cement replacement, in order to reduce the cement content (usually for economic reasons) and as an additive to improve concrete properties in both fresh and hardened states .

The main aim of this study is to investigate combined use of Ground-granulated blast-furnace slag and Kota stone powder slurry in concrete. Grade of concrete for the study has been chosen as M40, as it offers good number of applications in the construction industry, ranging from PQC to buildings.

1.1 Raw Materials Characteristics

Ground granulated blast furnace slag

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. GGBFS is used to make durable concrete structures in combination with ordinary Portland cement or other pozzolanic materials. GGBFS has been widely used for its superiority in concrete durability, extending the life span of buildings from fifty to a hundred years. GGBFS reacts like Portland cement when in contact with water.

Kota stone powder slurry

Kota stone is the most commonly used building materials. The Industry's disposal of the Kota stone powder slurry material consisting of very fine particles. This Kota stone powder slurry having lime stone qualities because Kota stone is a fine grained variety of limestone. This Kota Stone Powder slurry is neglected as waste in several factories .

Super plasticizer

Super plasticizer (Sika-Plastiment) was used @ 0.7% of weight of cement. Specific gravity of Sika-Plastiment is 1.12 (as per manufacturer).

2. CONTROL MIX

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

Table -1: Mix Proportion for Control Mix (M40 Grade)

MATERIALS	QUANTITY
Cement (OPC-43)	363 kg/m³
Coarse aggregate	1148.9 kg/m³
Fine aggregate	902.75 kg/m³
Water	132 litres
Super plasticizers	2.54
W/C ratio	0.363

3. RESULTS

3.1 Slump

The Slump test results of control mix and concrete prepared with 20%, 30% and 40% replacement of cement by Ground granulated blast-furnace slag and 10%, 15% and 20% replacement of fine aggregate by Kota stone powder slurry.

Table -2: Slump Variation

GGBFS	Kota Stone Powder Slurry			
	0%	10%	15%	20%
20%	63	61	60	58
30%	65	62	61	60
40%	69	66	65	63
0% (Control)	58			

3.2 Compressive strength

The Compressive strength results of concrete specimens with 40% replacement of cement by Ground granulated blast-furnace slag and 10%, 15% and 20% replacement of fine aggregate by Kota stone powder slurry at the ages of 7, 28 and 56 days are presented in Table-3

Table -3: Variation in compressive strength with 40% GGBFS

OPC+GGBFS	SAND+KSPS	COMPRESSIVE STRENGTH (N/mm²)		
		7 DAYS	28 DAYS	56 DAYS
100+0	100+0	31.47	48.39	51.6
60+40	100+0	31.59	49.57	54.34
	90+10	29.81	48.13	53.29
	85+15	29.07	46.22	52.8
	80+20	27.88	45.82	52.12

The Compressive strength results of concrete specimens with 30% replacement of cement by Ground granulated blast-furnace slag and 10%, 15% and 20% replacement of fine aggregate by Kota stone powder slurry at the age of 7, 28 and 56 days are presented in Table 4

Table -4: Variation in compressive strength with 30% GGBFS

OPC+GGBFS	SAND+KSPS	COMPRESSIVE STRENGTH (N/mm²)		
		7 DAYS	28 DAYS	56 DAYS
100+0	100+0	31.47	48.39	51.6
70+30	100+0	30.34	47.23	52.63
	90+10	29.03	46.61	51.86
	85+15	28.40	45.24	51.2
	80+20	27.15	43.01	50.7

The Compressive strength results of concrete specimens with 20% replacement of cement by Ground granulated blast-furnace slag and 10%, 15% and 20% replacement of fine aggregate by Kota stone powder slurry at the age of 7, 28 and 56 days are presented in Table 5

Table -5: Variation in compressive strength with 20% GGBFS

OPC+GGBFS	SAND+KSPS	COMPRESSIVE STRENGTH (N/mm²)		
		7 DAYS	28 DAYS	56 DAYS
100+0	100+0	31.47	48.39	51.6
80+20	100+0	29.78	46.03	50.33
	90+10	28.53	44.39	48.75
	85+15	28.01	42.18	47.69
	80+20	26.8	41.73	47.11

Flexural strength

The Flexural strength results of concrete specimens with 40% replacement of cement by Ground granulated blast-furnace slag and 10%,15% and 20% replacement of fine aggregate by Kota stone powder slurry at the age of 28 days are presented in Table 6

Table -6: Variation in flexural strength with 40% GGBFS

OPC+GGBFS	SAND+KSPS	FLEXURAL STRENGTH (N/mm²)
		28 DAYS
100+0	100+0	4.69
60+40	100+0	4.96
	90+10	4.84
	85+15	4.67
	80+20	4.54

The Flexural strength results of concrete specimens with 30% replacement of cement by Ground granulated blast-furnace slag and 10%, 15% and 20% replacement of fine aggregate by Kota stone powder slurry at the age of 28 days are presented in Table 7

Table -7: Variation in flexural strength with 30% GGBFS

OPC+GGBFS	SAND+KSPS	FLEXURAL STRENGTH (N/mm²)
		28 DAYS
100+0	100+0	4.69
70+30	100+0	4.81
	90+10	4.62
	85+15	4.49
	80+20	4.33

The Flexural strength results of concrete specimens with 20% replacement of cement by Ground granulated blast-furnace slag and 10%, 15% and 20% replacement of fine aggregate by Kota stone powder slurry at the age of 28 days are presented in Table 8

Table -8: Variation in flexural strength with 20% GGBFS

OPC+GGBFS	SAND+KSPS	FLEXURAL STRENGTH (N/mm²)
		28 DAYS
100+0	100+0	4.69
80+20	100+0	4.71
	90+10	4.48
	85+15	4.2
	80+20	3.95

3. CONCLUSIONS

By evaluating the test results of Slump, Compressive Strength, Flexural Strength and Splitting Tensile Strength, following conclusions have been drawn-

Slump Values

The Value of slump increases with increase of GGBS content in the mix, but it slightly reduces with increase in the content of Kota stone powder.

Compressive Strength

Even by reducing cement content by 40% and replacing it by GGBFS, the compressive strength of M 40 Grade concrete does not decrease (at the age of 56 days) and it is observed to be almost similar to the control concrete (without GGBFS).

In the mixes with 40% GGBFS, if fine aggregate is partially replaced by Kota stone slurry powder in the range 10% to 20%, then also, compressive strength does not decrease (hardly variation of 1 to 3% was observed at the age of 56 days). At the age of 7 days and 28 days, the compressive strength of concrete with cement replaced by GGBFS by 40% is observed to be lesser than the control mix (without GGBFS).

Flexural strength

In the mixes with 40% GGBFS, if fine aggregate is partially replaced by Kota stone slurry powder in the range 10% to 20%, then flexural strength does not decrease (hardly variation of 1 to 3% was observed at the age of 28 days). But the strengths of the mixes with 20% and 30 % GGBFS with the same range of Kota stone slurry powder content were observed to be lesser than the control mix (without GGBFS).

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