Partial Replacement of Cement by Ground Granulated Blast Furnace Slag in Concrete

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Abstract: Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure. This paper presents an experimental investigation to know the use of Ground Granulated Blast Furnace Slag (GGBS) in concrete as a replacing agent of Ordinary Portland Cement (OPC) having 53 grades. The GGBS is a waste product from the iron manufacturing industry. GGBS produced when iron ore, coke and limestone fed into the furnace and resulting molten slag floats above the molten iron at 1500˚C to 1600˚C. The present paper focuses on investigating characteristics of concrete having M20 grade with partial replacement of cement by Ground Granulated Blast Furnace Slag (GGBS). Cement is replaced by 0%, 30%, 40% & 50% with GGBS and testing conducted like compressive strength test on cubes for 3 days, 7 days and 28 days and split tensile strength test on cylinders for 28 days. In this paper compressive strength of concrete is increased with a certain limit about 40% replacement of cement with GGBS and it slightly a reduced at 50% replacement respectively.

Key Words: Cement, Concrete, GGBS, Compressive Strength, Split tensile strength.

INTRODUCTION:

Concrete is typically an enormous individual material element in the built environment. Concrete is mainly comprised of Portland cement, aggregates, and water. GGBS concrete is a type of concrete in which a part of the cement is transformed by ground. Granulated blast furnace slag, which is an industrial excess. Ground Granulated Blast Furnace Slag (GGBS) is a cementations material that can

act as a partial replacement for Portland cement without significantly compromising the compressive strength. The components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%) and MgO (1-18%). Concrete property will be maintained with advanced mineral admixtures such as blast furnace slag powder as partial replacement of cement by 0%, 30%, 40%, and 50%. Compressive strength of blast furnace slag concrete with different dosage of slag is studied as a partial replacement of cement. The present paper focuses on investigating characteristics of M20 grade concrete with partial replacement of cement with Ground Granulated Blast Furnace Slag (GGBS) by replacing cement via 0%, 30%, 40%, 50%.

OBJECTIVES

1. To study the behaveour of concrete after replacing cement about 0%,30%,40% and 50%, by ground granulated blast furnace slag (GGBS).
2. To find out the optimum percentage of cement replacement level by GGBS for better strength and durability and characteristics of concrete
3. To utilized the blast furnace slag as an advanced construction material as it is enhancing the properties of the concrete
4. To find the supplementary cementations material as a partially replacement of cement
5. To prepare the concrete mix to increased durability and strength.

HISTORY OF GGBS

Following are some examples where the GGBS used in concrete.

1. World Trade Centre, New York (about 40% replacements).
2. Airfield Pavement of Minneapolis Airport (35 % replacement).
3. Atlanta, s Georgia Aquarium (worlds one of the largest aquarium), (20% to 70% replacements).
4. Detroit Metro Terminal Expansion (30% Replacement).
5. The Air Train linking New York's John Kennedy International Airport with Long Island Rail Road Trains (20% - 30% replacements).
6. T sings Ma Bridge, Hong Kong (59%-65%) replacement.

From the above examples it is cleared that the world is aware of the

advantages of GGBS uses in concrete. The

SR .NO	PARTICULARS	PROPERTY
1	$(CaO+MgO/3Al_2O_3)/(Sio_2+ 2/3Al_2O_{3)}$	0.8
2	MgO %	15
3	MnO %	4
4	Sulphide sulphur %	1.5
5	Insoluble Residue %	4.5
6	Glass content %	78

main aim of the use of GGBS is to improve

SR. NO.	PARTICULARS	PROPERTY
1	Color	Off white powder
2	Bulk density loose tones/m^3	1.0-1.1
3	Bulk density loose tones/m^3	1.2-1.3
4	Relative density	2.85-2.95
5	Surface area	400-600 m^3/kg

the durability, reduce the maintenance cost, to increase the service life, increase the economy of the construction with using the cheaper material as a replacement of the cement, and to reduce the cement consumption.

PHYSICAL AND CHEMICAL PROPERTIES OF GGBS:

Materials used and mix proportioning

1. Cement= 400 kg/m3

2. Fine aggregate= 600kg/m3

3. Coarse aggregate= 1180kg/m3

4. Water= 197lit

MIX PROPORTION FOR CUBES AND CYLINDERS

Materials	0%	30%	40%	50%
Cement(kg)	13.2	9.16	7.88	6.6
Fine aggregate(kg)	19.8	19.8	19.8	19.8
Coarse aggregate(kg)	38.94	38.94	38.94	38.94
GGBS(kg)	-	3.96	5.28	6.6
Water(lit)	6	6	6	6

CASTING AND CURING

For each mixes ,six cubes having size 150X150X150 mm and one cylinder having size 150X300 mm were casted and after 3 days,7 days and 28 days de-molding the specimens and cured in water at room temperature until they were tested.

TESTING COMPRESSIVE

TEST:

The compressive strengths of three 150mm x 150mm x 150mm test cubes were determined in accordance with BS EN 12390-3:2009: Testing hardened concrete: Compressive strength of test specimens. The specimens were tested for 3 days, 7 days and 28 day strengths.

TENSILE SPLITTING STRENGTH TEST:

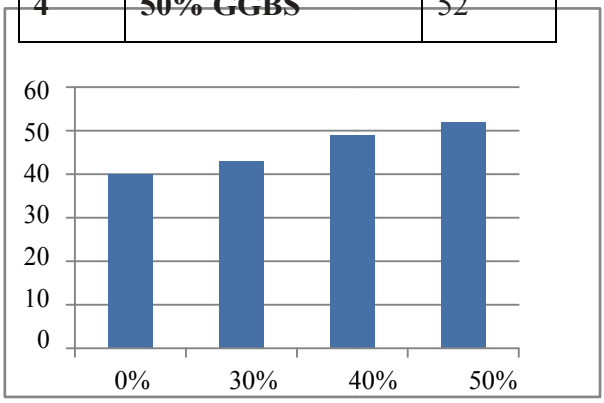
The tensile splitting strength of the three 150mm diameter, 300mm long cylinders was determined according to BS EN 12390-6:2009: Testing hardened concrete: Tensile splitting strength of test specimens after 28 days of curing.

RESULT AND DISCUSSION

1. Workability test results for different percentages of GGBS:

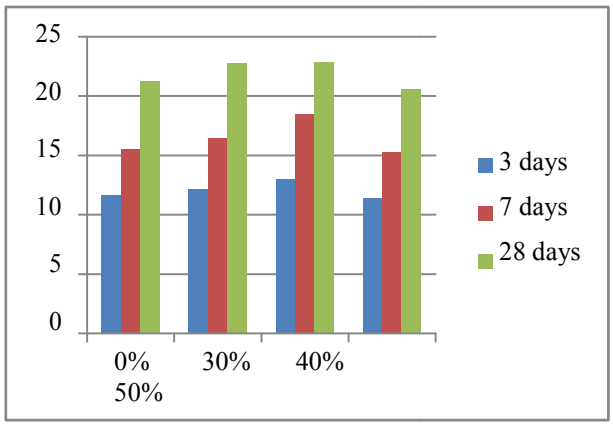
The result of workability test for different percentages of GGBS in concrete is presented in table. Bar chart of comparison for different percentages of GGBS is presented in bar chart

Sr. No	Type of Specimen	Slump Value in mm
1	Nominal concrete	40
2	30% GGBS	43
3	40% GGBS	49
4	50% GGBS	52



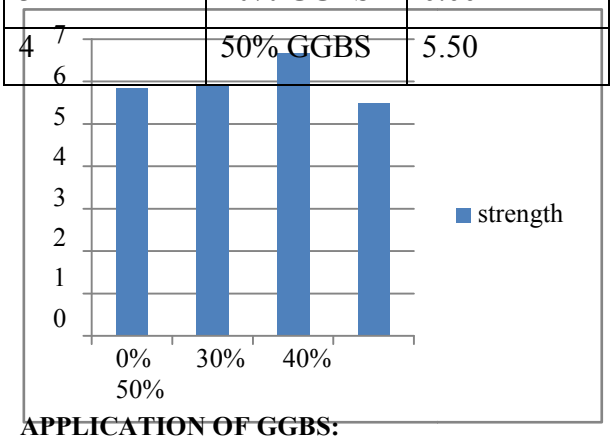
2. Result of compressive strength test for different percentage of GGBS:

sr. no.	Type of specimen	compressive strength N/mm^2		
		3 days	7 days	28 days
1.	Nominal concrete	11.66	15.55	21.22
2.	30% GGBS	12.20	16.44	22.78
3.	40% GGBS	13.00	18.44	22.88
4.	50% GGBS	11.38	15.33	20.56



3. Result on tensile strength for different percentages of GGBS:

Sr. no.	Type of specimen	Strength in N/mm^2 (for 28 days)
1	Nominal concrete	5.83
2	30% GGBS	5.88
3	40% GGBS	6.66
4	50% GGBS	5.50



APPLICATION OF GGBS:

It is characterized by energy savings, cement savings, low cost, environmental protection, environmental and social benefits as well as economic profit.

GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty year to hundred years.

GGBS is used to make durable concrete structures in combinations with ordinary Portland cement and or other Pozzolanic materials.

CONCLUSION:

Blast furnace slag concrete mix has various cement replacement level at different percentages, like 30%, 40% and 50% etc.

The optimum use of slag in the concrete is observed to be 40% of cement. Slag concrete with 40% cement shows higher compressive strength then OPC mortar after 28 days curing.

Use of high volume slag as a replacement of cement, in any

construction work provides lower impact on environment (reduced CO_2 emission) and economical use of resources (energy conservation, use of by-product etc.)

Use of slag reduces the amount of cement contain as well as heat of hydration in a mortar mix. Thus, the new slag concrete becomes economical and also environmentally safe.

Slower rate of hydration in case of slag cement concrete/mortar lower the risk of thermal cracking.

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