Strength and Corrosion Resistance Properties of Ggbs Concrete Containing Quarry Dust as Fine Aggregate

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***Abstract*—Demand for natural sand in concrete is increasing day by day. The experimental study undertaken to investigate the influence of partial replacement of cement with ground granulated blast furnace slag (GGBFS) in concrete containing quarry dust as fine aggregate. Tests were conducted to determine the optimum level of replacement of GGBFS in quarry dust concrete. GGBS is obtained as By-product of steel manufacturing industries. Now a days utilization of industrial soil waste or secondary materials has encouraged in construction field for the production of cement and concrete because it contribute to reducing the consumption of natural resources. The main focus of this study is to find out the strength, durability and Corrosion resistance properties of concrete in which fine aggregate is fully replaced by Quarry dust and Cement is partially replaced by 10%, 20%, 30%, 40% and 50% . The resistance to corrosion is evaluated based on the performance of the concrete for penetration of chloride ions by means of impressed voltage technique in saline medium and Gravimetric weight loss method.**

***Index Terms*—GGBS, quarry dust, calcium nitrate, compressive strength, durability, corrosion resistance**

I. Introduction

Concrete is the most widely used building material in the world due to its versatility, low cost and durability. Fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river sand. The demand for natural sand in the construction industry has consequently increased due to the extensive use of concrete resulting in the reduction of sand sources and increase in price. Natural sand takes millions of years to form and is not replenish able. Quarry dust, a byproduct from the crushing process of stones (Blue metal) which is available abundantly from rock quarries at low cost in many areas can be an economical alternative to the river sand. Quarry dust has been used for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks. Ground Granulated Blast Furnace Slag which is a by-product of steel manufacturing industry is an accepted mineral admixture for use in concrete due to its glassy nature and chemical composition which makes it pozzolanic and a cementitious material. In India we produce about 7.8 million tons of blast furnace slag. All the blast furnace slag is granulated by quenching the molten slag by high power water jet, making 100% glassy slag granules. The large scale depletion of these sources also creates environmental problems. Erosion and failure of river banks, lowering of river beds, damage to the bridge foundations and other structures situated closer to the rivers, saline water intrusion into the land and coastal erosion are the major adverse effects due to intensive river sand mining. Therefore, it becomes necessary to explore the possibilities for alternative sources to minimize river sand extraction. Thus, an investigation is needed to identify a suitable substitute that is eco-friendly and inexpensive and in this connection the use of quarry dust as fine aggregate has occupied a promising factor in the preparation of concrete.

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II. Materials and Methods

Cement-Cement is the important binding material in concrete. Ordinary Portland cement is the common form of cement. It is the basic ingredient of concrete, mortar and plaster. It consists of mixture of oxides of calcium, silicon and aluminium. Ordinary Portland cement (OPC) – 53 grades confirming to IS: 12269 – 1987 was used.

TABLE I. Physical Properties of Cement

Property	**Value**
Specific gravity	3.14
Initial setting time	40 minutes
Final setting time	6 hours
Fineness of cement	4%

As per IS 269: 2013, the results are within maximum limits.

GGBS-Ground Granulated Blast Furnace Slag which is a by-product of steel manufacturing industry is an accepted mineral admixture for use in concrete. This granulated material when further ground to less than 45micron is called Ground Granulated Blast Furnace Slag (GGBFS).

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TABLE II. PHYSICAL PROPERTIES OF GGBS

S.NO	Property	Value
1	Normal consistency	30%
2	Initial setting time in min	55minutes
3	Final setting time in min	9hours
4	Specific gravity	2.98
5	Fineness of cement by sieve	8%

The properties of GGBS are determined by conducting test in accordance with ASTM C 989 and their values are within the specified maximum limit.

A. Fine Aggregate

Sand-Sand is essentially quartz whereas clay is made of many other chemically active minerals like kaolinite. Sand between 4.75mm (about 5mm) and 0.15mm in size is called fine aggregate. Natural sand is available from local river beds or pits.

TABLE III. PHYSICAL PROPERTIES OF FINE AGGREGATE

S.NO	Name of Test	Observed Value
1.	Specific gravity	2.3
2.	Bulking of sand	11.1%
3.	Sieve analysis	2.6

As per IS 383: 1970, the results are within the maximum limits.

Quarry Dust-Quarry dust, a byproduct from the crushing process of stones (Blue metal) which is available abundantly from rock quarries at low cost in many areas can be an economical alternative to the river sand.

TABLE IV. PHYSICAL PROPERTIES OF QUARRY DUST

SL.NO	Property	Result
1	Specific gravity	2.55
2	Fineness modulus	3.0
3	Water absorption	3.8

As per IS: 2386 (PART – I) – 1963,the results are within the maximum limit.

Coarse aggregate-Material which are large to be retained on 4.7mm sieve size (say 5mm for convenience) are called coarse aggregate. A maximum size of 10mm is usually selected as coarse aggregates up tp20mm.

TABLE V. PHYSICAL PROPERTIES OF COARSE AGGREGATE

S.NO	Name of Test	Observed Value
1.	Specific gravity	2.88
2.	Sieve analysis	2.30
3.	Crushing test	12.2%
4.	Impact test	11.7%
5.	Flakiness index	36.65%
6.	Elongation index	45.2%

As per IS: 2386 (part III) of 1963,the results are within the maximum limit.

Water-Portable tap water available in the laboratory with pH value of 7.0 and conforming to the requirements of IS456-2000 is used for making concrete and curing the specimen as well. Water is an important ingredient of concrete as it actively participates in chemical reaction with cement.

B. Mix Design

Step 1: Target strength for mix proportioning

$$f'_{ck} = f_{ck} + 1.65 \text{ x } s$$

$$= 30 + 1.65 \text{ x } 5 = 38.25 \text{ N/mm}^2$$

where, S = standard deviation (S = 5 N/mm^2)

f_{ck} = characteristic compressive strength at 28 days

f'_{ck} = target average compressive strength at 28 days

Step 2: Selection of w/c ratio

Max w/c ratio = 0.45

w/c ratio = 0.40

Step 3: Selection of water content(Asper IS 10262-2009)

Table II, water content for 20mm aggregate = 186 lit

100mm slump = 186 + 6/100 x186 = 172 lit

172lit<186lit

Hence ok.

Step 4: Calculation of cement content

w/c ratio = 0.40

cement content = water content/ w/c ratio

= 172/0.4 = 430 kg/m^3

= 430> 320 kg/m^3

Step 5: Proportion of volume of coarse aggregate & fine aggregate content From Table III volume of CA corresponding 20mm size aggregate and FA (zone 2) for w/c of 0.5 = 0.62.In present case w/c = 0.4

Correct proportion of volume of CA for the w/c of 0.4 = 0.63

Volume of coarse aggregate = 0.62

Volume of fine aggregate = 0.38

Step 6: Mix calculation

The mix calculations per unit weight of concrete

a) Volume of concrete = 1m^3

b) Volume of cement = mass of cement / specific gravity of cement x (1/1000)

= 430/3.14 x 1/1000

= 0.136 m^3

c) Volume of water = mass of water / specific gravity of water x 1/1000

= 172/1 x 1/1000

= 0.172m^3

d) Volume of all in aggregate = [a-(b+c)]

= [1-(0.136 + 0.172)]

= 0.702 m^3

e) Mass of CA = d x Volume of CA x specific gravity of CA x 1000

Volume of CA = 0.62 m^3

Volume of FA = 1- Volume of CA

= 1- 0.62 = 0.38 m^3

CA = 0.702 x 0.62 x 2.8 x 1000
= 1218.67 kg

f) Mass of FA = d x Volume of FA x specific gravity of FA x 1000
= 0.702x 0.38 x 2.5 x 1000
= 667kg

TABLE VI. MIX RATIO FOR M_{30} GRADE CONCRETE

	Cement	Fine aggregate	Coarse aggregate	Water
By weight (kg)	430	667	1219	197
By volume	1	1.6	2.8	0.40

Hence the ratio is 1: 1.6: 2.8

Age of testing- The specimens to be used for the tests included concrete cubes of size 100mm × 100mm for compression test, cylinders of size 100mm diameter and 200mm height for split tensile strength test and beams of size 100mm × 100mm × 500mm for flexural test. The strength characteristics tests are to be conducted at 7, 28 and 60 days. The durability characteristics tests are to be conducted at 28 and 60 days.

III. RESULT AND DISCUSSION

TABLE VII. RESULTS OF COMPRESSION TEST AT 7TH DAY

Specimen	Compressive strength (N/mm^2)
Control concrete	28.5
Concrete with 10% GGBS	24.62
Concrete with 20% GGBS	26.84
Concrete with 30% GGBS	28.36
Concrete with 40% GGBS	29.23
Concrete with 50% GGBS	30
Concrete with 60% GGBS	27

TABLE VIII. RESULTS OF COMPRESSIVE TEST AT 28TH DAY

Specimen	Compressive strength (N/mm^2)
Control concrete	32.2
Concrete with 10% GGBS	28.7
Concrete with 20% GGBS	30.40
Concrete with 30% GGBS	31.8
Concrete with 40% GGBS	32.5
Concrete with 50% GGBS	33.89
Concrete with 60% GGBS	29.3

IV. CONCLUSION

It is concluded that Ground granulated blast furnace slag also has a lower heat of hydration and, hence, generates less heat during concrete production and curing. Increased resistance to chemical attack. The results of compressive test show that the strength of the concrete increases with respect to the percentage of GGBS slag added by weight of fine aggregate upto 50% of replacement. Therefore, the replacement of 50% GGBS is the better corrosion resistance.

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