An Experimental Investigation on Properties of Concrete by Partial Replacement of Cement with GGBS and Fine Aggregate with Quarry Dust

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Abstract: ***In the present study an investigation is made on properties of concrete by partial replacement of Cement with Ground Granulated Blast Furnace Slag (GGBS) and Fine Aggregate with Quarry Dust (QD). Ground Granulated Blast Furnace Slag is a by-product of Iron and Steel industry which is produced in large quantities as a solid waste. It is highly cementitious, Quarry Dust is used as a replacement of Natural Sand due to its scarcity. The replacement percentages of Cement with GGBS are 20%, 40% and 60% by weight and 25%, 50%, 75% and 100% of Quarry Dust are used as a replacement of Natural Sand. Various combinations of GGBS and Quarry Dust were prepared using M30 Grade of Concrete. The effect on these replacement materials on Compressive Strength, Split Tensile Strength, Flexural Strength, Modulus of Elasticity and Water Absorption were studied and the results obtained were compared with the Control Concrete. It is observed that the optimum replacement percentages of GGBS and Quarry Dust are 40% and 50% respectively.***

Keywords: GGBS, Quarry Dust, Partial Replacement, Compressive Strength

1. Introduction

Concrete is the most widely used construction material all over the World. The constituents of Concrete are Cement, Fine Aggregate, Coarse Aggregate and water. Cement acts as a binder material for Concrete. During its production of Cement, CO_2 is released into the atmosphere, which is harmful to the environment. Many researches have worked out on the ways of reducing the Cement Content which tends to the reduction in CO_2 emissions. Various by-products like FlyAsh, Slica Fume, Metakaolin, GGBS were used as a replacement for Cement. In this study. GGBS is used as a replacement for Cement.

Acute shortage and high price of Natural Sand tends to find an alternative material for it. Quarry Dust is used as a replacement of Natural Sand. the disposal problems can also be reduced because of its usage in the production of Concrete.

2. Objective

The main aim of the present work is to determine the strength characteristics of concrete by partial replacement of cement with GGBS and Fine aggregate with Quarry Dust for application in structural concrete, which will give better understanding on the properties of concrete. The effect of GGBS and Quarry Dust (QD) on the properties of Concrete are studied.

3. Experimental Programme

3.1 Properties of Materials

3.1.1 Cement

The cement which is used in the present study is UltraTech Ordinary Portland Cement (OPC) of 53 grade. The properties of Cement are confirming to IS 12269-1987 Specifications.

3.1.2 Fine Aggregate

Fine Aggregate which is used in the study is locally available and it conforms to IS Specifications. The properties are shown in Table No.1

Table 1: Physical properties of Fine Aggregate

S.No	Property	Result
1	Specific Gravity	2.52
2	Fineness Modulus	3.76
3	Zone	Zone – II

3.1.3 Coarse Aggregate

Coarse aggregate of nominal size 20 mm and 12 mm, obtained from the local quarry confirming to IS specifications was used. The properties of Coarse aggregate are shown in Table No.2

Table 2: Properties of Coarse Aggregate

S.No	Property	Result
1	Specific Gravity	2.67
2	Water Absorption	0.4 %

3.1.4 Ground Granulated Blast Furnace Slag (GGBS)

GGBS is obtained from AASTRA chemicals, Chennai. Properties of GGBS are presented in Table No.3

Characteristics	Test results
Fineness Modulus	3.90
Specific Gravity	2.85
Insoluble residue	0.49

3.1.5 Quarry Dust

Quarry Dust is obtained from the local quarry near Chandragiri, Tirupathi , Andhra Pradesh. The properties of QD are shown in Table No.4

Table 4: Properties of Quarry Dust

S.No	Property	Result
1	Specific Gravity	2.3
2	Fineness Modulus	2.18
3	Water absorption	3.5%

3.1.6 Water

The water used for casting and curing of concrete test specimens was free of acids, organic matter, suspended solids and impurities which when present can adversely affect the strength of concrete.

3.2 Concrete Mix Proportion

M30 grade of concrete is used in the present investigation. The mix design is done as per Indian Standard Code of Practice.

Table 5: Quantities of Ingredients per m^3 of M30 Grade Concrete

S.NO	Cement (%)	QD (%)	GGBS (%)	Water (Lit)	Cement (kg)	QD (kg)	Fine Aggregate (kg)	GGBS (kg)	Coarse Aggregate (kg)
1	100	0	0	165	375	0	778	0	1199
2	100	25	0	165	375	194.5	583.5	0	1199
3	100	50	0	165	375	389	389	0	1199
4	100	75	0	165	375	583.5	194.5	0	1199
5	100	100	0	165	375	778	0	0	1199
6	80	25	20	165	300	194.5	583.5	75	1199
7	80	50	20	165	300	389	389	75	1199
8	80	75	20	165	300	583.5	194.5	75	1199
9	80	100	20	165	300	778	0	75	1199
10	60	25	40	165	225	194.5	583.5	150	1199
11	60	50	40	165	225	389	389	150	1199
12	60	75	40	165	225	583.5	194.5	150	1199
13	60	100	40	165	225	778	0	150	1199
14	40	25	60	165	150	194.5	583.5	225	1199
15	40	50	60	165	150	389	389	225	1199
16	40	75	60	165	150	583.5	194.5	225	1199
17	40	100	60	165	150	778	0	225	1199

4. Results and Discussions

4.1 Compressive Strength

The Compressive strength test carried at the age of 3,7,28 and 56days. The load is applied gradually until the specimen fails. the load at failure divided by area of the specimen gives the Compressive Strength of Concrete.

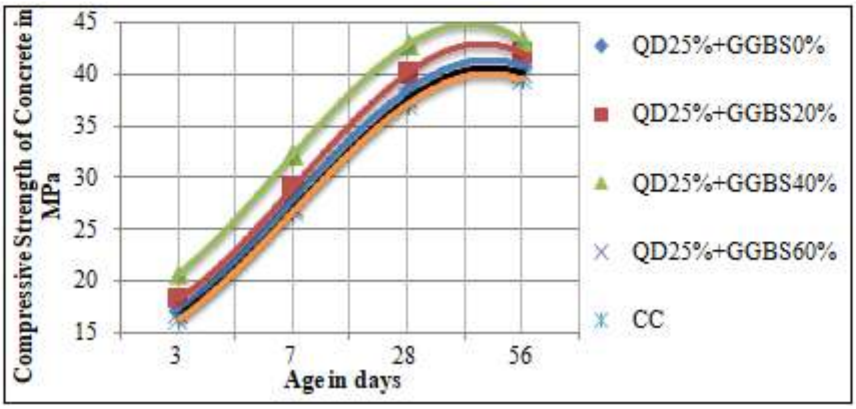

Figure 1: Compressive Strength variation at different percentages of GGBS and 25% QD

From the graph it can be observed that the compressive strength of concrete increases with increase in age. The maximum strength occurred at a replacement of Cement by 40% GGBS and Sand by 25% Quarry Dust. The Compressive Strength results of Concrete for other combinations of GGBS and QD are shown in Figs 2 to 4

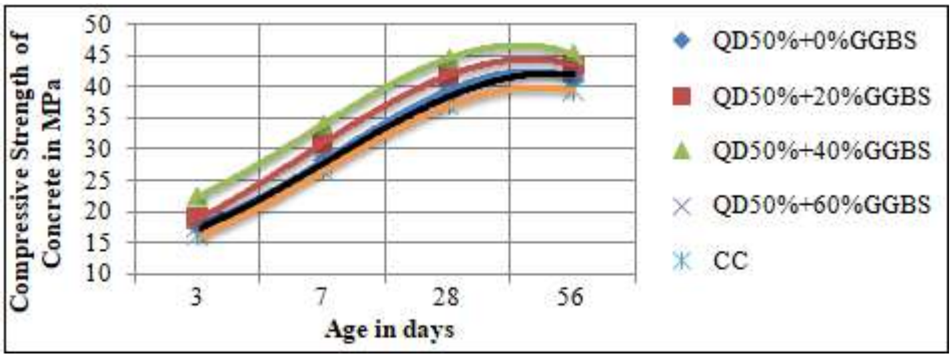

Figure 2: Compressive Strength varaiation at different percentages of GGBS and 50% QD

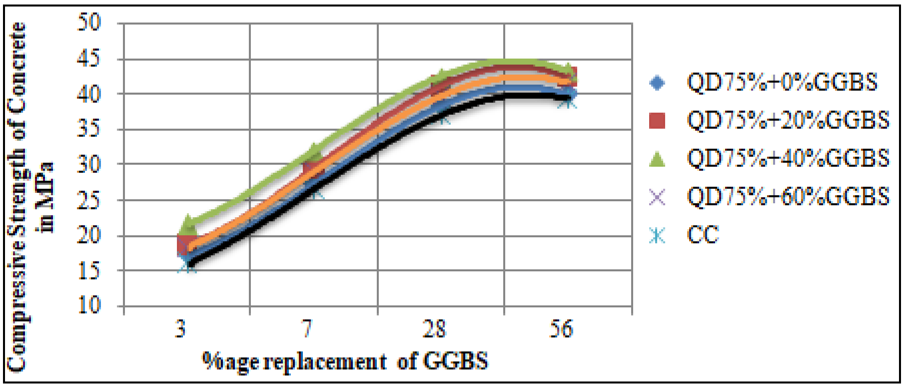

Figure 3: Compressive Strength varaiation at different percentages of GGBS and 75% QD

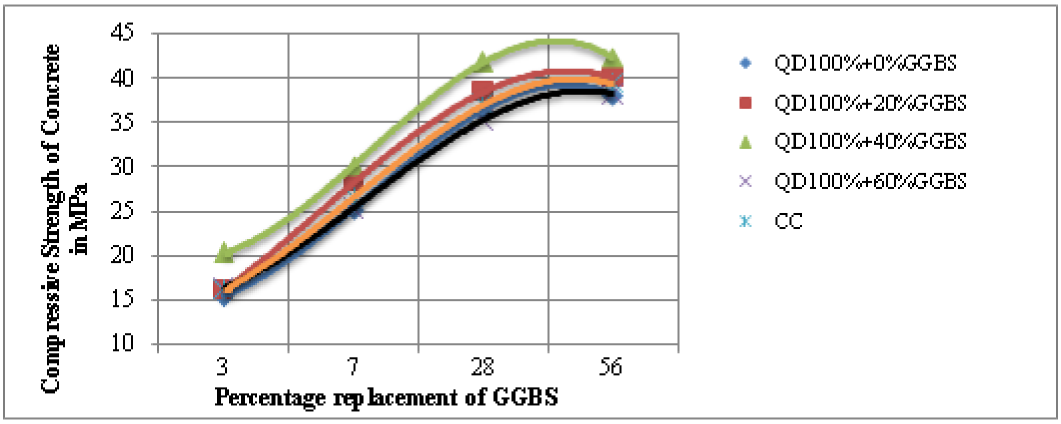

Figure 4: Compressive Strength varaiation at different percentages of GGBS and 100% QD

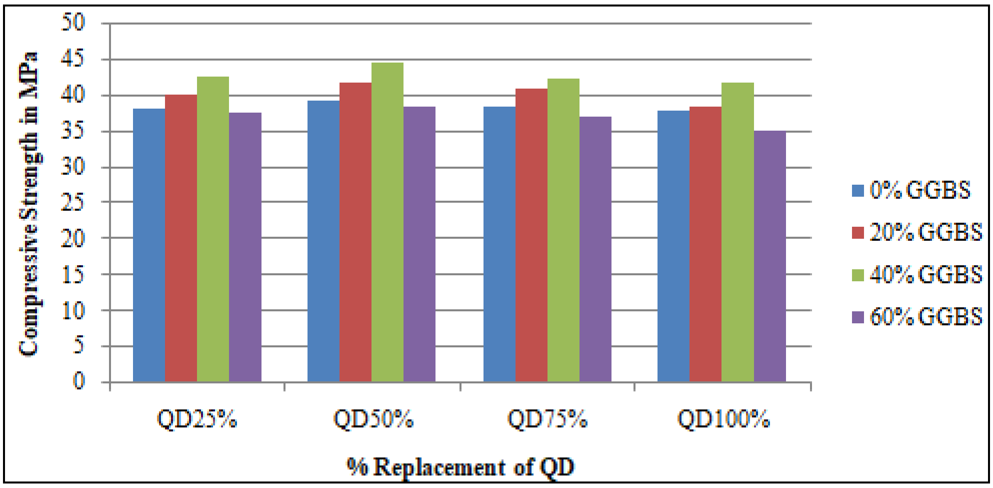

Figure 5: Compressive Strength varaiation at 28 days with different percentages GGBS and QD

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From the Fig.5 it is observed that the maximum strength occurred at 40% replacement of Cement with GGBS and 50% replacement of Fine Aggregate with Quarry Dust

Table 6: Percentage increase in Compressive Strength at 28 days for optimum mix proportion

Concrete Mix	Compressive Strength (MPa)	% Increase
Control Concrete	37.8	-
GGBS40% + QD50%	44.6	18

4.2 Split Tensile Strength

The variation of Split tensile Strength of Concrete obtained using cylinder specimens of size 150mmx300mm is shown in Fig.6

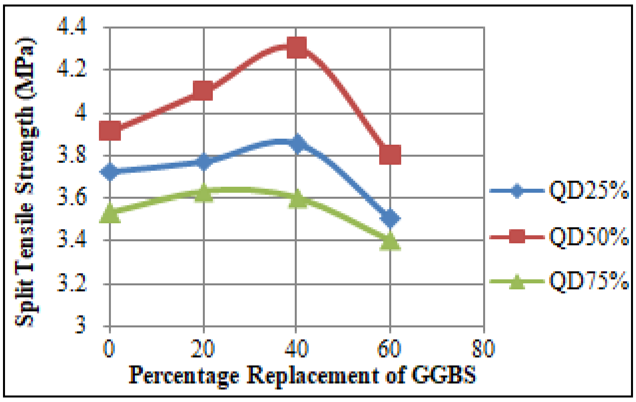

Figure 6: Split Tensile Strength variation for different percentages of GGBS and QD

From the Fig.6 it is clear that the maximum Split tensile strength of Concrete occurred at a replacement 40% GGBS and 50% Quarry Dust. The same trend can be observed for the various combinations of GGBS and QD.

Table 7: Percentage increase in Split Tensile Strength at 28 days for optimum mix proportion

Concrete Mix	Split Tensile Strength in MPa	% Increase
Control Concrete	3.63	-
GGBS40%%+QD50%	4.3	18.4

4.3 Flexural Strength

Flexural Strength is a measure of tensile strength of concrete prisms of size 500mmx100mmx100mm were used. Flexural strength is also known as Modulus of Rupture. It is a measure of unreinforced concrete beam to resist failure in bending.

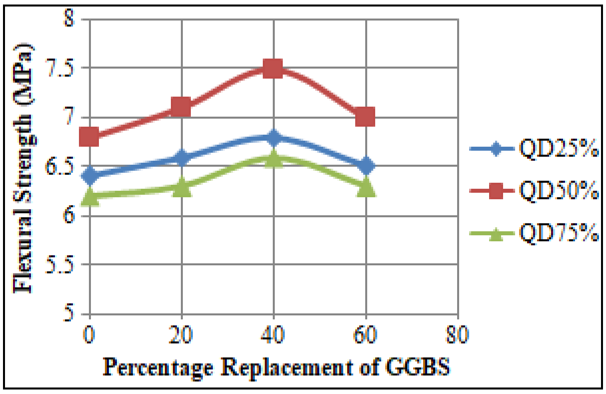

Figure 7: Split Tensile Strength variation for different percentages of GGBS and QD

The maximum flexural strength occurred at a percentage of 40% GGBS and 50% Quarry Dust. Beyond the maximum replacement levels the strength decreases.

Table 7: Percentage increase in Flexural Strength at 28 days for optimum mix proportion

Concrete Mix	Flexural Strength in MPa	% Increase
Control Concrete	5.8	-
GGBS40%%+QD50%	7.5	29

4.4 Modulus of Elasticity

Modulus of Elasticity of Concrete is obtained by testing cylindrical specimens of size 300mmx150mm in Compression.

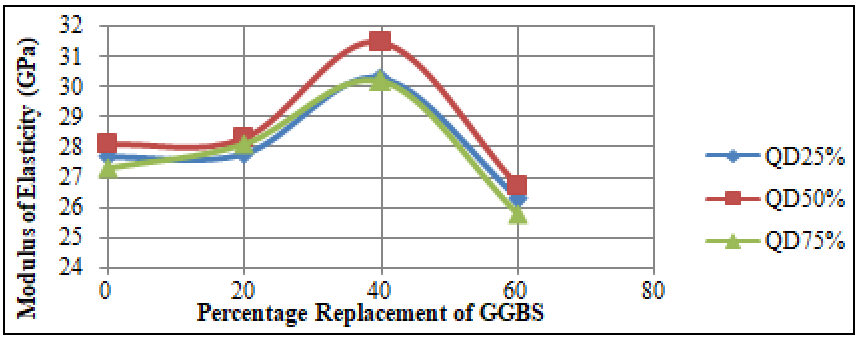

Figure 8: Modulus of Elasticity variation for different percentages of GGBS and QD

4.5 Water Absorption

Water Absorption test was conducted on Concrete cubes of size 150mmx150mmx150mm. The cubes were cast and tested at the age of 56 days.

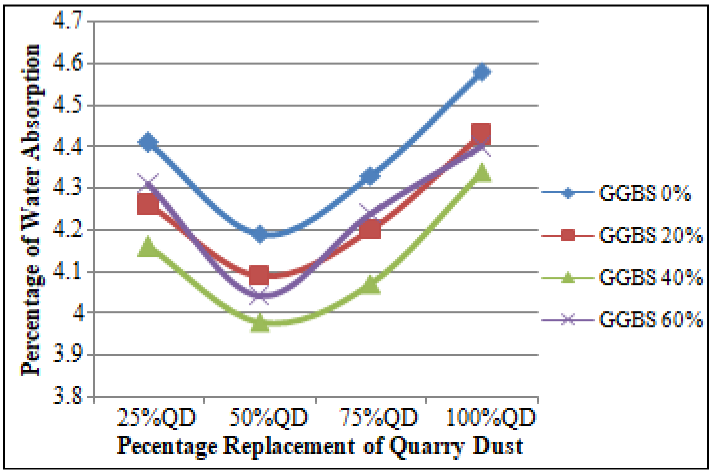

Figure 9: Variation of percentage Water Absorption for different percentages of QD and GGBS

From the Fig.9 it is observed that the Water Absorption decreases from 25% to 50% of Quarry dust. Beyond the optimum replacement percentages water absorption increases due to the presence of more dust particles.

5. Conclusions

- From the test results, an increment of 18% in Compressive Strength at 28 days is observed with 40% GGBS and 50% Quarry Dust.
- The maximum percentage increase of 23.5 % in Split Tensile Strength compared to control concrete and it is obtained at 40% GGBS and 50% Quarry Dust replacement.
- The maximum percentage increase of 29% in Flexural Strength compared to control concrete is obtained at 40% and 50% replacements of Cement and Fine Aggregate with GGBS and Quarry Dust respectively.
- At 40% and 50% replacement with GGBS and Quarry Dust respectively, Modulus of Elasticity of Concrete is 31.5 GPa where as Control Concrete has Modulus of Elasticity of 27.4GPa.
- At a replacement percentage of 40% cement with GGBS and fine aggregate with 50% Quarry Dust , the Water Absorption has the minimum value.
- Finally it is very interesting to note that the variation of various test results followed the similar trend.

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